ISBN: 978-93-94819-25-2

ADVANCES IN GEOGRAPHICAL RESEARCH

Editors
Dr. Namdev V. Telore
Dr. Sharad A. Borude

Advances in Geographical Research

Felicitation Volume Dedicated
To
Professor Maya G. Unde

Editors
Dr. Namdev V. Telore
Professor
Department of Geography
Raja Shripatrao Bhagawantrao Mahavidyalaya, Aundh, Satara,
Affiliated to Shivaji University, Kolhapur, India.

Dr. Sharad A. Borude
Associate Professor
Department of Geography
Ahmednagar College, Ahmednagar
Affiliated to Savitribai Phule Pune University, Pune

Jyotikiran Publication, Pune

Advances in Geographical Research

Editors
Dr. Namdev V. Telore, Dr. Sharad A. Borude

Publishing Agency
Jyotikiran Publication, Pune, India

Publisher Address
Santosh Pandurang Mane
Sr. No. 204, Sahajeevan Society,
Bhekrinagar, Hadpsar, Pune-8, India
Mob- 8888454089
Email- jyotikiranpublicationpune@gmail.com
Website: https://jkpub.in

Printed By
Amitsons Digital Copier 106, Paras Chamber, 1st Floor, Above Bank Of India, Near Laxminarayan Theatre, Swargate, Pune- 411009, India

Edition Details: Ist

ISBN: 978-93-94819-25-2

Copyright: © Dr. Namdev V. Telore, Dr. Sharad A. Borude

Publication Date: 30/06/2023

Price: RS. 500/- or USD. 10 /-

Preface

It is the proud moment for any academician to be felicitated at the retirement with publication of a good and useful volume like the present one. Professor Maya G. Unde deserves such felicitation. I join with all the young friends who wish her happy retirement by acknowledging her contribution in Geography. It is certainly far more than her teaching experience, research activities and cocurricular efforts. It is my privilege to be her teacher long time back. I could recognize her qualities since then. As a student she exhibited clarity in her understanding of the subject. She was robust hardworking student and remained the same throughout her career. Hardworking nature and sincerity have become her second nature and hence she could shoulder the responsibilities as the leader of postgraduate teaching and research Centre at Ahmednagar College with so much easement and inclusive approach.

Her inclusive approach could accommodate several first-generation learners in higher education and research work. There are some learned scholars in the field of Geography who are either with rural background or from the countries where medium of instruction was Persian. She had not only given them lessons how to upgrade knowledge but also enthused them to work hard on their linguistic problems. Her mentoring was so excellent that it can be considered as loveable motherhood. She is such a great personality! It is in this sense we, the students, scholars and the community of geographers owe her a lot.

Dr. Maya is the scholar of international repute. She has presented her work in the conferences held not only in India but also abroad. She has visited Australia and China for academic purpose. Her work on confluence of the streams in the environment of polycyclic landform of Maharashtra has been well praised and cited by international scholars in Geomorphology. Eventually, she became one of the internationally reputed geomorphologists. This is clearly seen through the topics, mentored by her. These are related to study of confluences, flood risk assessment along Bhima River from India and Binalood Mountain zone in Iran, Geomorphic assessment for planning Watershed Development, etc. She has also guided the work having great social and political relevance. For example, application of Geoinformatics to understand Naxalists' movements, Impact assessment of brick kilns, urban sprawl, issues of grocery shops after emergence of Malls, etc.

Her research experience and knowledge can be evidenced in the book, 'Flood Risk Analysis of River Godavari', authored by Dr. Maya and published by German publication. It is certainly relevant to government level planning for flood zone areas in the state. Furthermore, it is also useful for the scholars in hydrology, geomorphology and geoinformatics all over the world as it gives application of various models and methodology to procure data. Thanks to Mayatai for such a commendable work.

A teacher is known by his or her students. The scholars who chose her as their supervisor are also the internationally reputed scientists in the field of physical as well as

human geography. This is well exhibited in the present volume, "**Advances in Geographical Research**". I am aware of the sincere and hard work put in by the editorial committee, mainly to make this volume as per UGC rules. They have followed those rules stringently by assessing the articles for plagiarism, acquiring double blinded reviews and editing the work in book format. My wholehearted thanks to them for a great job done. The volume has presented about 22 articles coming from all over India, covering the states like Maharashtra, Karnataka, Uttarakhand, Assam, Arunachal Pradesh, etc. The topics covered in the book are ranging from plastic waste, grocery shops, urban heat islands and urban forestry, electric vehicles, etc. to organic fertilizers as a leverage to agricultural development. Obviously, it also includes articles on the topics related to climate change, impact of floods, research methodology, application of GIS and R. S. etc., mainly related to Dr. Maya's specializations. The book is useful to the students and research scholars as well. In my opinion, the book is a 'must purchase' one for the college and university libraries.

I wish Dr. Maya and her students a great time ahead.

Dr. Praveen G. Saptarshi
Visiting Professor in Salisbury University, USA
Professor and Head (Retd.), Department of Environmental Sciences,
Savitribai Phule Pune University, Pune, India.
Email- praveen.saptarshi@gmail.com

A Legacy of Dedication: Honoring the Career of Professor Maya Unde

In academia, certain teachers stand out not only for their expertise but also for the profound impact they leave on their students and the broader academic community. Professor Maya Unde, our esteemed Geography professor, exemplifies this rare combination of scholarly excellence and dedicated mentorship. As we bid farewell to a career marked by unparalleled contributions to the field, it is only fitting to reflect on the indelible mark left by Professor Maya Unde.

Throughout her tenure at our college, Professor Maya Unde has been a beacon of inspiration for students aspiring to understand the intricacies of her chosen field – Geography. Her teaching transcended the traditional boundaries of the classroom, as she imparted not only knowledge but also an enthusiasm for the subject. The genuine passion that Professor Unde brought to each lecture and discussion ignited a curiosity in countless students, encouraging them to explore the far-reaching implications of Geography.

Beyond the confines of teaching, Professor Unde distinguished herself through groundbreaking research that has significantly enriched the academic landscape. Her commitment to pushing the boundaries of knowledge of Geography has not only elevated the prestige of our college but has also contributed meaningfully to the global discourse within the field. Her numerous publications, research projects, and collaborations underscore a career dedicated not just to personal achievement, but to advancing the collective understanding of our world.

As we celebrate Professor Unde's retirement, it is crucial to acknowledge the impact she has had on the academic community. Her leadership, mentorship, and collaborative spirit have fostered an environment of intellectual growth and camaraderie. Colleagues and students alike have been fortunate to witness firsthand the transformative influence of Professor Unde's guidance.

Professor Unde leaves behind a legacy that transcends the pages of textbooks and academic journals. Her dedication to the field of Geography, coupled with a genuine investment in the intellectual development of others, has set a standard of excellence that will endure for generations. As we express our deepest appreciation for the remarkable career of Professor Unde, we also extend our warmest wishes for a retirement filled with the same joy, fulfillment, and inspiration that she has graciously shared with us throughout her tenure.

Dr. R. J. Barnabas
Principal
BPHE Society's
Ahmednagar College, Ahmednagar, M.S
Email: ahmednagarcollege1947@gmail.com

Editor's message

With immense pleasure, we present to you 'Advances in Geographical Research', an edited book that embodies a collaborative endeavour showcasing diverse perspectives and expertise in the Indian subcontinent. Each chapter enriches the tapestry of knowledge, delving into topics like Urban Heat Island, Flood Geomorphology, Quantitative Morphometric Analysis, Land Use Land Cover Change, Assessment of Forest Canopy Density, Spring Geomorphology, Slum Eviction, Urban Sprawl, Urbanization, land suitability analysis, Agro-Climatic Planning, Agricultural Development, Adoption of Electric Vehicles, Migration and Sustainable Development Goals, Interdisciplinary Research, Remote Sensing, Geographical Information System and allied topics of physical and human geography.

This volume serves as a felicitation to our mentor, Professor Maya G. Unde of B.P.H.E. Society's Ahmednagar College, Savitribai Phule Pune University, India. The book includes the research work by professors, planners, scientists and research scholars from various universities and institutions of India such as Forest Research Institute, National Institute of Advanced studies, Assam University, Central University of Haryana, Magadh University, Rajiv Gandhi University, Shivaji University, Savitribai Phule Pune University, University of Mumbai, Dr. Babasaheb Ambedkar Marathwada University, R.T.M. Nagpur University, K.B.C. North Maharashtra University, S.N.D.T. Womens University, Rural Development Department, Government of Sikkim, University of Calcutta, Hemvati Nandan Bahuguna Garhwal University, Banaras Hindu University.

We extend our sincere gratitude to the dedicated authors who have shared their knowledge and experiences. Their contributions have not only enriched this compilation but also advanced the discourse in Geography. We express our gratitude to the esteemed reviewers from various Universities for their invaluable contributions and to Professor Praveen G. Saptarshi, Visiting Professor in Salisbury University, USA for writing the Preface of the book. Special thanks to Hon. Ajitdada Pawar Saheb, Deputy Chief Minister, Government of Maharashtra and President of Aundh Shikshan Mandal (ASM), Aundh, Dist. Satara along with Hon. Shrimant Gayatridevi Pantpratinidhi, Ranisaheb Aundh, Chairman ASM; Hon. Charusheela Raje Pantpratinidhi, Vice Chairman, ASM; Secretary, Vice Secretary, Trustees and Members of ASM for providing necessary support. Also thankful to Principal Dr. S.S. Sawant, Raja Shripatrao Bhagawantrao Mahavidyalaya, Aundh and Principal Dr. R.J. Barnabas, Ahmednagar College, Ahmednagar for their unwavering support. We are thankful to Dr. J.D. Barkade, Dr. S.M. Kore, Dr. S.G. Annapure, Dr. P.C.

Bedarkar, Dr. M.S. Jdahav and all faculty members our colleagues from affiliated colleges for constant encouragement.

We are grateful to the felicitation volume committee members Dr. Subash Dhakal, Dr. Pandurang R. Bidkar, Dr. Azam Hajiabadi, Dr. Ashali Kharke, Dr. Manisha Pawar, Dadasaheb R. Jawre, Ajay V. Kakade and Jagruti Mahajani for their cooperation. We are tankful to research scholars Prakash Shinde, Yuvraj Kadam and Prashant Salve for their help in compilation of work. We are also grateful to Mr. Santosh P. Mane of Jyotikiran Publication, Pune.

We hope that 'Advances in Geographical Research' serves as a valuable resource for scholars, students, and enthusiasts alike. May it inspire further exploration and dialogue within the dynamic realm of Geography of Indian subcontinent. Thank you for embarking on this intellectual journey with us.

Namdev V Telore
Sharad A Borude
Editor(s)

About Editors

Dr. Namdev V. Telore is a distinguished Professor in the Department of Geography at Raja Shripatrao Bhagawantrao Mahavidyalaya, Aundh, Satara, affiliated with Shivaji University, Kolhapur, India. He earned his MA and PhD in Geography from Savitribai Phule Pune University, Pune. With a teaching career spanning over two decades, Dr. Telore is guiding Ph.D. students, authored a reference book on 'Geomorphology and Watershed Management', and contributed over 25 research papers to peer-reviewed national and international journals. His areas of specialization encompass Geomorphology, Watershed Management, and geospatial technologies. He is a member of various academic societies – IGU Commission on Research Methods in Geography, NAGI, ISRS, IIG, IGI, DGS, MBP and others.

Dr. Sharad A. Borude is Associate Professor in the Department of Geography at Ahmednagar College, Ahmednagar affiliated with Savitribai Phule Pune University, Pune, India. With a teaching experience of more than 22 years at UG and PG level, Dr. Borude is guiding 4 Ph.D. students. Dr. Borude co- authored 5 reference books, published over 18 research papers to peer-reviewed national and international journals and completed one research project funded by Savitribai Phule, Pune University, Pune. His areas of interest are mainly Population Geography, Rural Settlement and Urban Geography. He is a member of various academic societies like DGS, MBP.

Contents…

1. Biography of Professor Maya Gopinath Unde
Dadasaheb R. Jawre **1**

---

2. Role of Urban Forests in Mitigating the Urban Heat Island Effect: A Comprehensive Review
Haffis Mohammed, Hashim Mohammed S **10**

---

3. Geographical Information System and Remote Sensing Based Assessment of Forest Canopy Density (FCD) of Toranmal Forest Range (TFR) in Nandurbar District, Maharashtra.
Mohan. A. Vasave, Sandip. B. Garud **20**

---

4. Urban Land use Land cover change detection in Phaltan City of Satara District Maharashtra using Geospatial Technology
Prakash S. Shinde, Namdev V. Telore, Rahul S. Chaure **32**

---

5. Evaluation of Morphometric Characteristics The Bhima River Basin, Maharashtra using Geospatial Techniques
Pandurang R. Bidkar, Maya G. Unde, Namdev V. Telore **45**

---

6. Assessment of the GIS Based Characterization of Channel Morphology and Sinuosity Indices In Part of Floodplain in the Waingangā River, Maharashtra, India
Ravindra Bhagat **56**

---

7. Dhara Vikas: A climate change initiative to revive drying springs in Sikkim Himalayas
Subash Dhakal, Sher Bahadur Karki **66**

---

8. Multi-Criteria Land Suitability Analysis for Agriculture in Semi-Arid Region of Tirora Tehsil, Middle India: Geospatial Approaches
Sharad A. Borude, Nanabhau Kudnar, Vasudeo Salunke **101**

---

9. Geographical Analysis of Land Use Dynamics in the Ghod River Basin
Hanumant D. Shinde **116**

---

10. Agro-Climatic Planning for Sustainable Agricultural Development: A case Study of North Chotanagpur Plateau
Basudeo Prasad **124**

---

11. A Geographical Analysis of the Evolution of Grocery Stores into Shopping Centers in the City of Pune
Manisha Sanjay Pawar **141**

---

12. An Analysis of Factors Influencing In Adoption of Electric Vehicles By Buyers: A Case Study of Lucknow City
Jyoti Singh, Krishna Kumar Verma **155**

---

13. An Analytical Study of Use Organic Fertilizers in Agricultural Development
Balasaheb Raghunath Chakor, Kishor Devidas **166**

---

14. Tribal Population Density in the Akole Tehsil, Ahmednagar District, Maharashtra State
Pramila Popatrav Zaware, Vasudev Salunke,Tukaram D. Gajar **177**

---

15. A Critical Study On The Problem Of Spreading Waterborne Diseases Related To Dissolving Chemicals And Its Effect In Vichumbe Village.
Raviprakash D. Thombre **183**

---

16. Urban Expansion and Its Consequence on Landuse Landcover of Fringe Areas of Nagpur City
Jagruti Mahajani, Maya G. Unde **199**

---

17. Facts and Effects of Plastic Wastes Disposal
Sudhakar J. Borase **212**

---

18. Socio-economic impact of flood: A case study of the Jiadhal River Basin, Dhemaji district, India
Pranamee Gogoi, S. K. Patnaik, Tashi Dorjee Megeji **224**

---

19. Interdisciplinary Horizons of Changing Trends in Geographical Research
Ankita Raju Khobragade **235**

---

20. Land Use/ Land Cover Monitoring in Dharuhera Town of Haryana
Parag Jyoti Kashyap, Sachin Kumar **247**

---

21. Migration Dynamics: Unraveling the Interconnected Web of Migration and Sustainable Development Goals
Harpreet Singh **255**

22.Using geographic information systems and remote sensing together
Achole Pandurang Bapurao **266**

---

23. Forced Slum Eviction: A Silent Catastrophe in Indian Metropolitan Cities
Satarupa Dasgupta **280**

Index **300**

Biography of Professor Maya Gopinath Unde

Dadasaheb R. Jawre
Assistant Professor and Head, Department of Geography, Arts, Science and Commerce College, Burhannagar, Dist. Ahmednagar, Maharashtra, India.
E-mail: drjawre9@gmail.com

Article DOI Link: https://zenodo.org/records/10559026
DOI: 10.5281/zenodo.10559026

Abstract:

This chapter deals with biography of Professor Maya Gopinath Unde. She worked as a Professor in the Department of Geography at Ahmednagar College, Ahmednagar since 1999, which is affiliated with Savitribai Phule Pune University, Pune, and Maharashtra, India. Before coming Ahmednagar, she worked as a lecture in Shivaji University, Kolhapur. She has more than 3 decades teaching and research experience. Madam Unde was a research co-ordinator from 2007 and head of the department from November 2013. Prof. Unde has guided 09 Ph.D. students and completed 07 research projects which were sanctioned by different funding agencies of Government of India. There are 39 research papers, 03 books and 01 edited volume on her name. Prof. Unde has visited Australia in 2009 and China in 2016 regarding research work. She was awarded the Avishkar Foundation's Best Research Award in 2022 and the Global Foundation's National Level Best Teacher Award in 2023.

Keywords: Professor Maya Unde, Geography, Teaching and Research Experience.

Introduction:

Professor (Dr.) Maya Gopinath Unde was born in Baramati district Pune in Maharashtra, India. She did her primary education in Yawat, Tal. Daund, in Pune district and since, 11th standard to Batchelor of Arts she took education from S. P. College, Pune. She completed her Master degree from Savitribai Phule Pune University, Pune. B.Ed. completed from Aadarsh College, Pune. M.Phil. and Ph.D. work completed under the guidance of Professor S. R. Jog at the Department of Geography, Savitribai Phule Pune University, Pune.

She worked as a project fellow of CSIR funded project under the supervision of Prof. S. R. Jog during 1986-1989 and that time she teaches Geography subject in the Spicer College, Pune. She joins as a lecturer on temporary basis at Department of Geography, Shivaji University, Kolhapur during 5th December 1996 up to 25th August 1999.

From 26th August 1999 she has been permanently joined at Ahmednagar College, Ahmednagar in the Department of Geography as a lecturer. That time department provide education only graduation level. She started post-graduation level from 2000 and she became a research guide in 2003 and started Research Centre in 2006,

since, she was the co-ordinator of this research centre. From this research centre there are 11 candidates has successfully completed Ph.D. and awarded degree. Ph.D. registered candidates are 16, out of them 03 candidates have submitted their Ph.D. synopsis.

She was the Head of the Department from November 2013 to her superannuation. She became a professor in 2017. Her specialisation is Geomorphology, GIS and Remote Sensing and Research interest in River Morphology, Flood Risk, Sand Excavation, Watershed Management, Urban Geomorphology. She guided many students for Ph.D. and her students also become a Professor at different reputed Colleges and Universities. She published 39 research papers in Peer-Reviewed and UGC care listed journals. She visited abroad twice, Australia in July 2009 and China in August 2016. She published 03 books and edited 01 volume. She has competed 07 research projects funded by BCUD, Savitribai Phule Pune University, Pune, UGC and ICSSR New Delhi.

She was member of academic council and member of research committee of Ahmednagar College for many years. She has life membership of many academic bodies in the field of Geography. Since November 2014 she was a co-ordinator of IIRS outreach programme which is run by ISRO, Government of India.

She was a Member of Board of Studies in Geography during 2015-2020 of Savitribai Phule Pune University, Pune and Member of Board of Studies at Bhavan's college Mumbai from 2021 for the ten years. She Organized International Interdisciplinary Conference with Collaboration of Maharashtra Bhugolshastra Parishad Pune at Department of Geography, Ahmednagar College, and Ahmednagar during 18th and 19th January 2023.

Professor Maya Unde madam has received following Prestigious Awards:

1. Adarsh Vidya Saraswati Rashtriya Puraskar, by Global Management Council, Ahmedabad on 22nd July 2018.
2. Best Research Award 2022 from Aviskar Foundation, Solapur on 27th February 2022.
3. National Level Best Teacher Award by Global Foundation (GF), India on 21st April 2023.

Foreign Visits of Professor Maya Unde madam:

1. Australia – July, 2009.
2. China - August, 2016.

List of Ph.D. Degree Awarded Candidates under the guidance of Prof. Maya Unde madam:

Sr. No	Name	Place
1	Dr. Subash Dhakal	Sikkim
2	Dr. Pandurang Bidkar	Daund
3	Dr. Azam Hajiyabadi	Iran
4	Dr. Namdev V. Telore	Aundh, Satara
5	Dr. Manisha Pawar	Pune

6	Dr. Ashali Kharke	Nashik

List of ongoing Ph.D. Candidates under the guidance of Prof. Maya Unde madam:

Sr. No	Name	Place
1	Mr. Ajay V. Kakade	Ahmednagar
2	Mr. Dadasaheb R. Jawre	Ahmednagar
3	Ms. Jagruti Mahajani	Pune

Research Project Completed by Professor Maya Unde Madam:

Sr. No	Title of the project	Funding Agency	Amount Sanctioned	Status of the project
1	Mapping of Red bole around Ahmednagar city	UGC Mar. 2004-2006 **File No. – 23-63/2003** **Dated: 17th Feb. 2004**	40,000=00	Completed
2	Morphology of the Potholes observed in Dongargan Area of Ahmednagar District	UGC Jan. 2007-2009 **File No. – 23-213/06** **Dated: 29th Dec. 2006**	75,000=00	Completed
3	Application of ANN into basin shape analysis using Remote Sensing Data	BCUD Jan. 2007-2009 **File No. – BCUD/578** **Dated: 10th January 2007**	50,000=00	Completed
4	Flood Risk Analysis of River Godavari in Maharashtra: From Nashik Upto Puntamba	UGC Feb. 2009-2011 **File No. 34-84/2008(SR)** **Dated: 29th Dec. 2008**	5,32,200=00	Completed
5	Landslide Hazard Zonation Mapping using GIS Technique: A Case Study of Malshej Ghat Area, Maharashtra	BCUD May. 2009-2012 **File No. BCUD/OSD/184** **Dated: 11th May 2009**	2,80,000=00	Completed
6	Impact of Sand Mining in River	UGC Apr. 2013-2016	13,34,300=00	Completed

	Godavari and Bhima in Part of Maharashtra	**File No. 42-76/2013(SR) Dated: 12th March 2013**		
7	Impact of Urban Transformation on Rivers in Ahmednagar District, Maharashtra	IMPRESS – ICSSR July 2019 – June 2021 **File No. IMPRESS/P577/2018-19/ICSSR Dated: 8th July 2019**	8,00,000 = 00	Completed

Different Photographs of Professor Maya Unde madam:

Principal Dr. R. J. Barnabas felicitate to Professor Maya Unde madam on the occasion of Women's Day

UG students wined 1st prize in Intercollegiate Geography Quiz Competition Principal Dr. R. J. Barnabas felicitate Prize Winners in presence of Professor, Maya Unde, HOD and all staff members in the Department of Geography.

Professor Maya Unde has presented Research Paper in 7th International conference of Geomorphology at Melbourne, Australia in July 2009.

Professor Maya Unde, during field visit at Melbourne, Australia in July 2009.

Professor Maya Unde, attend and Present Research Paper in 33rd International Geographical Congress which was held at Beijing, China August, 2016.

Professor Maya Unde, Visited Great Wall of China during field visit of 33rd International Geographical Congress.

Professor Maya Unde with Dr. Swati Barnabas, guest speaker for Ph.D. course work at Research Centre in Geography during August - September 2022.

Professor Maya Unde delivered a lecture on Research Methodology in Ph.D. Course work, which was organised by Research Centre in Geography during August - September 2022.

39th MBP International Interdisciplinary Conference Organised, Department of Geography, Ahmednagar College Ahmednagar during 18th and 19th January 2023.

Professor Maya Unde madam discussed with India's Waterman Dr. Rajendra Singh regarding watershed management and allied issues.

Professor Maya Unde madam discuss with the local people of my study area in Chandani Watershed near Manikdaundi, Pathardi tahsil in June 2018.

Professor Maya Unde madam and me during field survey of River Nani after flash flood of August 2021 at Akhegaon in Shevgaon tahsil of Ahmednagar district.

My Experience about Professor Maya Unde madam:

Since my admission to the Department of Geography at Ahmednagar College, Ahmednagar, for post-graduation in 2006, madam has taught me the theory of geomorphology in the first semester, fluvial geomorphology in the second semester, geomorphology practical in the third semester, and in the final semester, under the supervision of Dr. Maya Unde madam, I have completed my PG dissertation.

After completed post-graduation, I have joined as a project fellow, project sanction to madam from UGC entitled "Flood Risk Analysis of River Godavari in Maharashtra: From Nashik up to Puntamba" from July 2009 to March 2011, I learn many things from madam while working as a project fellow and project successfully

completed. In 2013 again I have joined another project as a project fellow under the guidance of Unde madam project entitled “Impact of Sand Mining in River Godavari and Bhima in Part of Maharashtra” which is completed in 2016. While working on research projects I have get more research experience as well as published research papers. I have learned how to write research papers and published it in reputed journals. I got an opportunity worked as a co-project director of which was sanctioned to madam from IMPRESS ICSSR, New Delhi, during 2019 -2021.

After qualified the UGC NET, I started working as an Assistant Professor in the Department of Geography in July 2016 under the capable direction of HOD, Dr. Maya Unde madam. I will remain there till May 2023. I registered for a Ph.D. programme in March 2018 under the guidance of Professor Dr. Maya Unde madam. The title of the doctoral dissertation is ‘Watershed Management Analysis of Shevgaon and Pathardi Tahsils in Ahmednagar District’.

Madam has taught me many things about academic as well as administrative. Madam has always supported me and my family. Everything I achieved in the geography subject was only made possible by the respected Professor (Dr.) Maya G. Unde, madam. I will continue to look for madams guidance going forward.

I hope she enjoys a long, happy and prosperous life after retirement.

Role of Urban Forests in Mitigating the Urban Heat Island Effect: A Comprehensive Review

Haffis Mohammed
Technical Assistant, Forest Research Institute, Dehradun 248195 Uttarakhand, India.
Email: haffismohammed06@gmail.com
Hashim Mohammed S
PhD Scholar, National Institute of Advanced Studies, Indian Institute of Science Campus, Bengaluru 560012, Karnataka, India.
Email: mohammedhash@nias.res.in

Article DOI Link: https://zenodo.org/records/10559032
DOI: 10.5281/zenodo.10559032

Abstract:

The rapid growth of the global urban population has led to significant changes in land use and land cover, resulting in the emergence of Urban Heat Islands (UHIs), where urban areas experience higher temperatures than their surrounding rural counterparts. This review paper examines the crucial role of urban forests in combating the urban heat island effect and other climate-related risks associated with unplanned urbanization. Effective urban forest management strategies offer multiple benefits, including reduced storm water runoff, decreased wildfire risk, lower urban heat island temperatures, decreased utility costs, increased economic growth, and improved provision of clean drinking water. Moreover, urban trees act as vital carbon sinks, sequestering CO_2 from the atmosphere and aiding in long-term climate change mitigation. Increasing tree canopy cover emerges as a targeted approach by cities to address urban heat island temperatures and stormwater runoff, while simultaneously offering significant advantages in terms of carbon storage, sequestration, habitat creation, and biodiversity conservation. By implementing measures to promote and expand urban forests, cities can achieve sustainable urban development, enhance the quality of life for citizens, and mitigate the impacts of climate change.

Keywords: Urban forest, Urban Heat Island, Urban Forest Management, Climate Change, Carbon Sequestration.

Introduction:

The rapid increase in global urban population is a growing concern, with cities now accommodating 54% of the world's population (UN Habitat, 2016). According to the UN World Urbanization Prospects 2018, urbanization is occurring at an alarming rate, with the proportion of urban population rising from 30% in 1955 to 55% in 2018. It is projected that the urban population will reach 5 billion by 2030. This accelerated urbanization and industrialization have resulted in significant changes to land use and

land cover in modern cities, impacting the quality of life and lifestyles of citizens both positively and negatively.

One major negative consequence of urbanization is the rise in ambient urban temperature and urban warming. Unplanned urbanization can lead to the formation of Urban Heat Islands (UHI), which are local climate phenomena where urban areas experience higher temperatures compared to surrounding rural areas (Landsberg, 1981). In light of this, city planners must prioritize long-term solutions to mitigate the urban heat island effect and other climate-related risks associated with rapid urbanization.

Urban forest management has emerged as a key area where cities are progressively implementing policies to address the impacts of climate change. Comprehensive urban forestry planning offers numerous benefits, including reduced storm water runoff, decreased wildfire risk and intensity, mitigation of urban heat islands, lower utility costs, increased economic growth, and improved provision of clean drinking water. Urban trees also play a crucial role as long-term carbon sinks by absorbing CO2 from the atmosphere. While increasing tree canopy cover is often targeted by cities to combat urban heat island temperatures and stormwater runoff, it also has significant advantages in terms of carbon storage, sequestration, habitat creation, and biodiversity conservation.

Benefits of Urban Forests:

The term "urban forest" encompasses all trees within densely populated areas, including those in parks, street ways, and private properties (Sudha, 2000). While the composition, health, age, extent, and costs of urban forests vary among cities, they offer common environmental, economic, and social benefits. Extensive data supports the notion that trees in a community help reduce air and water pollution, regulate heating and cooling costs, and enhance real estate values. Moreover, trees have been proven to improve physical and mental health, foster social connections, and contribute to reduced crime rates (Wolfe, 2012). Green spaces, such as trees and community gardens, encourage outdoor activities, promote active living, and instill a sense of neighborhood pride.

Carbon Capture and Energy Savings:

Urban forests, like any forest ecosystem, play a crucial role in mitigating climate change by capturing and storing atmospheric carbon dioxide through photosynthesis. They also influence energy needs for heating and cooling buildings. Trees typically reduce cooling costs, but their impact on winter heating use varies depending on their location around buildings and whether they are evergreen or deciduous. Trees provide shading and reduce wind speed, leading to a decrease in carbon emissions by lowering the demand for summer air conditioning and winter heating. Consequently, this reduces the emissions from power plants (Nowak et al., 2010).

Provision of Usable Goods:

The sustainable utilization of wood, food, and other goods provided by local urban forests can help mitigate climate change by displacing imports associated with higher carbon dioxide emissions from production and transportation. Urban wood is an undervalued resource. By manufacturing forest products from felled urban trees and utilizing them at current rates, several hundred million tons of CO2 can be saved over a 30-year period (Nowak et al., 2010). Additionally, converting low-quality urban wood into wood chips for combustion can replace fossil fuels, resulting in a further reduction of approximately 2.1 million tons of emissions per year.

Adaptation to Climate and Weather Changes:

Urban forests play a vital role in helping cities adapt to the effects of climate change, particularly temperature patterns and weather events. Urban areas tend to be warmer than their surroundings, with temperature differences ranging from 1 to 2°C, and even up to 10°C under certain climatic conditions (Bristow et al., 2012). This exacerbates the temperature increases caused by global warming. Urban forests mitigate this "heat island" effect by providing shade, reducing urban albedo, and promoting cooling through evapotranspiration (Lankao and Romero, 2008). Given that cities are also vulnerable to climate-related threats such as storms and flooding, urban trees can help mitigate runoff by capturing rainwater in their canopies and increasing the infiltration rate of precipitation. Cullington and Gye (2010) demonstrated that reducing storm water flow minimizes stress on urban sewer systems, thereby reducing the risk of hazardous combined sewer overflows.

Increased Community Resilience:

Urban forests provide critical social and cultural benefits that enhance community resilience in the face of climate change. Street trees hold spiritual value, foster social interaction, and contribute to a sense of place and belonging for residents. Forested urban areas generally exhibit stronger and more stable communities, which are essential for the development of effective long-term sustainable strategies to address climate change (Dandy, 2010).

Urban Heat Island (UHI):

The development of urban areas leads to significant changes in the landscape, with open land and vegetation being replaced by buildings, roads, and other infrastructure. This transformation from permeable to impermeable surfaces contributes to the phenomenon known as the Urban Heat Island (UHI), where the air temperature within urban centers is elevated compared to the surrounding rural areas.

Types of Urban Heat Islands

Surface Urban Heat Island:

During hot, sunny summer days, urban surfaces such as roofs and pavements can become significantly hotter, reaching temperatures 27 to 50°C higher than the air

temperature (Berdahl and Bretz, 1997). In contrast, shaded or moist surfaces in rural areas tend to remain closer to air temperatures. Surface urban heat islands are typically present day and night, but their intensity is greatest during daytime when the sun is shining. The magnitude of surface urban heat islands varies with seasons due to changes in the sun's intensity, ground cover, and weather, with the largest differences typically observed in the summer (Oke, 1982).

Atmospheric Urban Heat Island:

Atmospheric urban heat islands are characterized by warmer air in urban areas compared to the cooler air in nearby rural surroundings. There are two types of atmospheric urban heat islands:

Canopy layer urban heat islands exist in the layer of air where people live, extending from the ground to below the tops of trees and roofs. Boundary layer urban heat islands start from the rooftop and treetop level and extend up to the point where urban landscapes no longer influence the atmosphere. This region usually extends no more than one mile from the surface (Oke, 1982).

Factors Contributing to UHI:

Less Vegetation

In rural areas, vegetation and open land dominate the landscape, providing shading and reducing air temperatures through evapotranspiration. In contrast, urban areas are characterized by a scarcity of vegetation, with surfaces predominantly paved or covered by buildings. The lack of vegetative cover results in reduced moisture retention and evaporation, contributing to elevated surface and air temperatures.

Nature of Urban Materials:

The reflectance, emissivity, and heat capacity of urban materials play a role in UHI development. Urban construction materials often have low albedo, which is the ratio of reflected solar energy to incident solar energy. Albedo is influenced by surface orientation, heterogeneity, and the materials used for roofs, pavements, and coatings (Bouyer et al., 2009). Low albedo surfaces absorb more solar energy, leading to increased urban temperatures. Built-up areas generally reflect less and absorb more of the sun's energy, further exacerbating surface and atmospheric urban heat island formation.

Urban Geometry

Urban geometry refers to the dimensions and spacing of buildings within a city. It affects wind flow, energy absorption, and the ability of surfaces to emit long-wave radiation back to space. Urban areas are densely built, with structures often obstructing each other. This dense urban form hinders convection currents, trapping heat within the urban environment and contributing to larger thermal masses.

Human Gathering:

Urban centers often experience high human population densities due to the availability of various facilities. The gathering of people leads to significant emissions of

CO2, which acts as a heat-trapping greenhouse gas. The accumulation of CO2 contributes to the formation and intensification of the urban heat island effect.

Increased Use of Air Conditioners:

The widespread use of air conditioners for cooling purposes during summer also contributes to the UHI effect. Air conditioners release heat absorbed from the indoor environment to the outside, causing the surrounding atmosphere to warm up (Okwen, 2013). This further raises the atmospheric temperature.

Case study

Case Study 1: Impact of Urbanization and Land Surface Temperature Changes in a Coastal Town in Kerala (Arulbalaji et al., 2020)

The study conducted in the Akulam-Veli lake catchment, located on the outskirts of Trivandrum city in Kerala, examined the impact of urbanization on land surface temperature (LST) and land use/land cover changes. The area has experienced significant changes in land use since 2000, primarily due to residential, commercial, and road construction activities.

The analysis of land use/land cover changes revealed a decrease of 37.5% in vegetation cover and an increase of 39.6% in built-up lands from 1988 to 2019. Unplanned urbanization in the southern part of the study area, occupied by high-end households and corporate establishments, has resulted in environmental degradation.

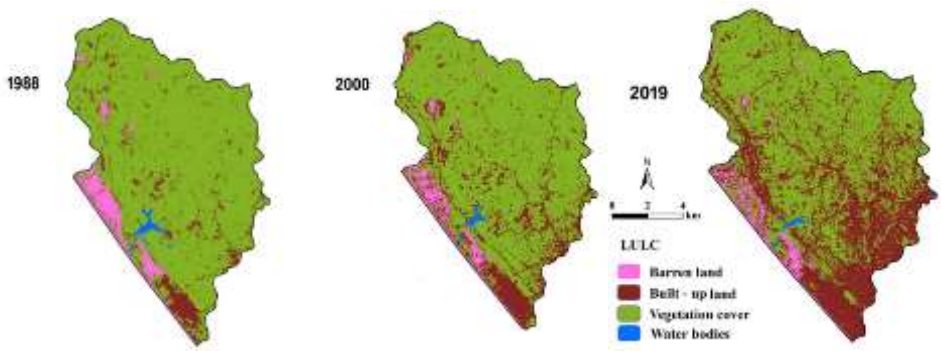


Figure 1: Maps showing Land use/land cover changes for the year 1988, 2000 and 2019

The study found that areas with high urban sprawl exhibited higher land surface temperatures, indicating the presence of urban heat islands (UHI). UHI was mainly distributed in regions with higher LST. These findings emphasize the urgent need for mitigation strategies in the study area, such as increasing green cover and reducing the amount of built infrastructure, to alleviate the adverse effects of UHI and rising temperatures.

Case Study 2: Scale-Dependent Interactions between Tree Canopy Cover and Impervious Surfaces Reduce Daytime Urban Heat during summer

This study aimed to understand the interactions between tree canopy cover and impervious surfaces in influencing daytime and nighttime urban air temperatures during summer. The research was conducted in a midsized city in the Upper Midwest United States, using a bicycle-mounted measurement system to collect air temperature data along transects spanning a range of canopy and impervious cover percentages.

The results showed that variability in daytime air temperature within the urban landscape averaged 3.5 °C, with temperature decreasing nonlinearly as canopy cover increased. The greatest cooling effect was observed when canopy cover exceeded 40%. The magnitude of daytime cooling also increased with spatial scale, with the most significant cooling occurring at the size of a typical city block (60-90m radius).

Daytime air temperature increased linearly with increasing impervious cover, but the magnitude of warming was less than the cooling effect associated with increased canopy cover. In contrast, nighttime air temperature increased with impervious surface cover, while the effects of canopy cover were limited at night. Thus, reducing impervious surfaces remains critical for mitigating nighttime urban heat.

The study suggests that the most effective urban heat mitigation strategies should involve modifications to both green (canopy cover) and grey (impervious surfaces) infrastructure. The cooling effect of trees can significantly offset the warming effect of impervious surfaces, especially when canopy cover exceeds 40% within a radius of 60-90m, roughly equivalent to a city block. As cities continue to experience climate warming, urban forestry plays a crucial role in regulating daytime temperatures and has the potential to enhance temperature regulation services in urban areas worldwide.

Strategies to Reduce Urban Heat Island:

According to Sailor (2006) the mitigation of urban heat island effect can be done in two ways. One is by increasing the albedo of the urban surface and the other is by increasing evapotranspiration. However, the major strategies to mitigate the UHI effect are described below:

High Albedo Roofing Materials:

Dark roofs absorb heat from the sunlight and make houses warm. In contrast, light coloured roofs with similar insulation properties do not get warmed significantly by reflecting solar radiation (Akbari *et al*., 2001). So, the choice of roofing colour can contribute to temperature reduction. Roofing materials with low albedo absorb solar heat and make the house warm which results in high consumption of energy for air conditioning. So, one of the mitigation strategies is to use high albedo roofing materials.

High Albedo Pavements:

More solar radiation could be reflected if the road and highway pavements were of high albedo materials (Akbari *et al.,* 2001). So, proper selection of pavement materials can also contribute to the reduction of UHI effect. Levinson and Akbari(2002) suggested some reflective concrete surfaces after curing various concrete mixes of albedo ranging

from 0.41 to 0.77. Sailor (2006) suggests that white cement mixtures can be made for which the albedo should be higher than the most reflective grey cement mixtures.

Vegetative cover:

Urban green spaces are considered an appropriate way to reduce urban heat island effects and provide comfort to the nearby occupants. In addition to cooling the actual space, urban green spaces are also able to influence the surrounding area, and this phenomenon is called the urban green space cooling effect. The most important issues regarding the cooling effects of urban green spaces are the intensity and density of the cooling, which can play a major role for urban designers and planners in dealing with urban heat island.

Trees provide direct cooling of the microclimate through shading, evapotranspiration, and carbon sequestration. They, simultaneously induce indirect cooling of the environment through reduced demand for cooling energy, thus lowering carbon emissions from power plants (Akbari *et al.,* 2001).

Greenery systems mainly comprised of green roofs and green walls are initially considered in the architectural style of the buildings. The integration of greenery systems to buildings in urban areas has a great potential to increase the quality of urban environment such as providing water and air quality, dense vegetation in urban environments, a marked decline in temperature and carbon emissions as well as minimization of heat island effects (Vijayaraghavan,2016). It also imparts aesthetic beauty to the urban system.

Green Roofs:

According to Wong (2005) roofs in the cities represent about 21% to 26% of the city area. So, if the roofs are made green by vegetating, it will act a major role in mitigating the UHI effect. Green roofs absorb heat and filter the air, keeping the temperature low (Getter 2006). Plants utilize heat energy to continue their evapotranspiration process, making the environment cool. In addition to it, green roofs help to delay the runoff duration which will keep the cities cooler for a longer period (Getter 2006). As it also absorbs water, it keeps itself cooler, helping to reduce the temperature. Again, green roofing will bring energy balance to the corresponding building by keeping the energy demand low.

Roofs account for nearly 20–25% of overall urban surface areas. Therefore, greening the roofs has a great potential to affect the building and urban environment. Green roofs, also known as eco-roofs, roof gardens and living roofs can be defined as the roofs coated with green vegetation and growing medium (Vijayaraghavan,2016). Green roofs reduce greenhouse gas emissions, air pollution and urban heat island effects in highly populated areas, provide better ecological habitat for urban life and wildlife, absorb local noise pollution within urban areas. Energy saving, thermal insulation, shading and evapotranspiration features highlight the key role of green roofs in overall thermal

performance of buildings and microclimatic conditions of indoor environments (Tang and Qu,2016).

Vertical greenery systems:

The use of vertical greenery helps in energy saving and ecological improvements for both buildings and urban areas. Vertical greenery systems also play a key role in providing microclimate and increasing the biodiversity and air quality (Pan and Chu,2016). The vertical greenery system is named as vertical garden, green wall, vertical green, vertical landscaping, and bio walls.

Miyawaki Forest: The Miyawaki method, also called the Potted Seedling Method, is an afforestation technique that uses native species to create dense, multi-layered forests. This technique is very useful for urban area since it required less land. Maximum tree intensification within minimum land is a core objective of the Miyawaki forest. The overall density of the forest is beneficial in lowering temperature, making soil nutritious, supporting local wildlife and sequestration of carbon.

Figure 3: Miyawaki forest at Barapullah, Delhi

Conclusion:

In conclusion, urban forests stand as crucial allies in the ongoing battle against the Urban Heat Island (UHI) effect, presenting diverse benefits for both the environment and local communities. The implementation of effective urban forestry planning becomes instrumental in countering the escalating temperatures linked with haphazard urbanization. A targeted approach involving the strategic augmentation of tree canopy cover not only addresses UHI temperatures and stormwater runoff but also brings about additional advantages such as carbon storage, habitat creation, and biodiversity conservation. The two case studies presented, particularly the examination of land surface temperature changes in a coastal town in Kerala and the investigation into the interplay between tree canopy cover and impervious surfaces in a midsized U.S. city, exemplify the real-world impact of urban forests in mitigating heat-related challenges. Urban trees play a pivotal role in carbon capture, serving as vital long-term carbon sinks. By leveraging the cooling effects of shade, minimizing urban albedo, and enhancing evapotranspiration, urban forests emerge as powerful tools in alleviating the UHI

phenomenon, contributing to a more resilient and sustainable urban environment. Furthermore, the provision of usable goods, such as wood and other forest products, underscores the practical and ecological significance of urban forests in fostering climate resilience and enhancing the overall quality of urban life.

References:

1. Akbari, H., Pomerantz, M., & Taha, H. (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Journal of Solar Energy, 70(3), 295-310. https://doi.org/10.1016/S0038-092X(00)00089-X
2. Arulbalaji, P., Padmalal, D., & Maya, K. (2020). Impact of urbanization and land surface temperature changes in a coastal town in Kerala, India. Environmental Earth Sciences, 79(17), 1-18. https://doi.org/10.1007/s12665-020-09120-1
3. Berdahl, P., & Bretz, S. (1997). Preliminary Survey of the Solar Reflectance of Cool Roofing Materials. Energy and Buildings, 25, 149-158. https://doi.org/10.1016/S0378-7788(96)01004-3
4. Brown, R. D., Vanos, J., Kenny, N., & Lenzholzer, S. (2015). Designing urban parks that ameliorate the effects of climate change. Landscape and Urban Planning, 138, 118-131. https://doi.org/10.1016/j.landurbplan.2015.02.006
5. Dandy, N. (2010). Climate change & street trees project. The social and cultural values, and governance, of street trees, Forest Research. https://www.forestresearch.gov.uk/publications/the-social-and-cultural-values-and-governance-of-street-trees/
6. Kuehler, E., Hathaway, J., & Tirpak, A. (2017). Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network. Ecohydrology, 10(3), 52-98. http://dx.doi.org/10.1002/eco.1813
7. Landsberg, H. E. (1981). The urban climate. Academic Press, New York.
8. Nowak, D. J., & Crane, D. E. (2002). Carbon storage and sequestration by urban trees in the USA. Environmental Pollution, 116(3), 381-389. https://doi.org/10.1016/S0269-7491(01)00214-7
9. Okwen, R., Ruiliang, P., & Cunningham, J. (2011). Remote sensing of temperature variations around major power plants as point sources of heat. International Journal of Remote Sensing, 32(13), 3791-3805. http://dx.doi.org/10.1080/01431161003774723
10. Pan, L., & Chu, L. M. (2016). Energy saving potential and life cycle environmental impacts of a vertical greenery system in Hong Kong: a case study. Building and Environment, 96, 293-300. http://dx.doi.org/10.1016/j.buildenv.2015.06.033
11. Rosenzweig, C., Solecki, W. D., Romero-Lankao, P., Mehrotra, S., Dhakal, S., & Ibrahim, S. A. (2018). Climate change and cities: Second assessment report of the urban climate change research network. Cambridge University Press, UK, pp. 3-26.

12. Roth, M. (2007). Review of urban climate research in (sub)tropical regions. International Journal of Climatology, 27(14), 1859-1873. http://dx.doi.org/10.1002/joc.1591
13. Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban Forestry and Urban Greening, 11(4), 351-363. https://doi.org/10.1016/j.ufug.2012.06.006
14. Sudha, P., Ravindranath, N. H. (2000). A study of Bangalore urban forest. Landscape and Urban Planning, 47(1–2). https://doi.org/10.1016/S0169-2046(99)00067-5
15. Tang, X., & Qu, M. (2016). Phase change and thermal performance analysis for green roofs in cold climates. Energy and Buildings, 121, 165-175. https://doi.org/10.1016/j.enbuild.2021.110961
16. United Nations, Habitat. (2016). World Cities Report 2016 – Urbanization and Development: Emerging Futures [online]. Available: https://unhabitat.org/world-cities-report [06 Jan. 2021].
17. United Nations. (2018). World Urbanization Prospects Report 2018 [online]. Available: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf [17 Jan. 2021].
18. Vijayaraghavan, K. (2016). Green roofs: A critical review on the role of components, benefits, limitations, and trends. Renewable and Sustainable Energy Reviews, 57, 740-752. [https://doi.org/10.1016/j.rser.2015.12.119](https://doi.org/10.1016/j.r
19. Wolfe, M. K., Mennis, J. (2012). Does vegetation encourage or suppress urban crime? Evidence from Philadelphia, PA. Landscape and Urban Planning, 108(2–4). https://doi.org/10.1016/j.landurbplan.2012.08.006

Geographical Information System and Remote Sensing Based Assessment of Forest Canopy Density (FCD) of Toranmal Forest Range (TFR) in Nandurbar District, Maharashtra.

Mohan. A. Vasave
Assistant Professor, Department of Geography, Arts, Commerce and Science College Taloda 425413 Dist. Nandurbar, Maharashtra, India.
E-mail: mohanvasavegeo@gmail.com
Sandip. B. Garud
Assistant Professor, Department of Geography, Arts, Commerce and Science College Taloda 425413 Dist. Nandurbar, Maharashtra, India.
E-mail: sandipgarud71@gmail.com

Article DOI Link: https://zenodo.org/records/10559045
DOI: 10.5281/zenodo.10559045

Abstract:

An essential tool for good resource management is the assessment of forest canopy density (FCD). The precise location of the forest gaps within a given area can be determined by the vegetation cover density, which can then enable future management plans. A vital tool for pinpointing the precise locations where reforestation or afforestation programs need to be carried out is forest canopy density. To examine the forest canopy density in the Toranmal Forest Range (TFR), Nandurbar District, Maharashtra, weighted overlay analysis has been used. For this investigation, number of indices like NDVI, BSI, AVI, and SI etc. were used. Greater concentrations of vegetation were given a higher weight, whereas lesser concentrations of vegetation were given a lower weight. In comparison to the northern part of the study area, the southern and centre portions have a fairly high density of forest cover. 7.48% of the land is of very low density, 0.75 per cent at low density, 4.8 per cent at medium density, 22.3 per cent at high density, and 33.1 per cent at very high forest canopy density.

Keywords: Density, Canopy, Management, Forest Cover.

Introduction:

A large expanse of land that is covered in trees, bushes, and woodland is known as a forest. Similar to this is a thick mass of vertical or tangled objects, primarily composed of trees, that can be anywhere from a few kilometres to thousands of kilometres in size. There are many different kinds of forests there, including equatorial, tropical deciduous, tropical evergreen, tropical rainforest, Mediterranean, moderate temperate broadleaved mixed, and coniferous woods. Forests have always been a crucial source of restoration since the dawn of human civilization. The most important ingredient for humans is produced in forests. Important ecological and economic

ramifications result from it. With the advancement of science and technology, along with remote sensing and geographic information system techniques, the spatial forest health or forest condition of an area can be detected (Coppin & Bauer, 1994). The Forest Canopy Density (FCD) model is a fundamental tool to understand the forest crown condition of an area and it aids us in making decisions for sustainable forest management. In addition to having an adverse impact on continuous patches and the quality of the forest, fragmentation is a critical element that contributes to the loss of habitat, biodiversity, and ecosystem services.

Fragmentation is a non-random process whereby human-made development results in the conversion of forest area to land used for agriculture, settlement, roads, and other purposes. According to Sandhya Kiran and Ramandeep Kaur (2011), there has been a significant increase in human disturbances, which has put additional strain on the world's forests, particularly tropical forests. This has led to progressive deforestation and degradation of the forest's surface. Forest fragmentation is the gradual division of vast, unaltered forest stretches into a collection of tiny, irregularly shaped, and isolated pieces. The primary driver of the geographical distribution of biodiversity, climatic change, and the degradation of forest ecosystem services is anthropogenic forest fragmentation. The species composition, abundance, and natural regeneration are also impacted (Bentez Malvido & Martnez Ramos, 2003).

Remote sensing is the most precise and efficient technique for identifying past and present forest dynamics, both at a spatial and temporal scale. It may provide information on a location's forest cover effectively and economically, and the output can be received in the form of maps that illustrate the location's forest cover. Numerous geographic and mathematical categorization methods, including maximum likelihood, neural networks, and logistic regression, can be used to find spatiotemporal changes in forest dynamics. To define and forecast land use or forest cover, numerous researchers also employed specific hybrid models that combined several models. One such technique is the random forest classifier, which is well-liked for its ease of use, speed, and accuracy (Huang et al.2002).

Objectives:

1. To assess spectral vegetation indices of the Toranmal forest range in Nandurbar district
2. To analyse the forest cover change detection in the Toranmal forest range.
3. To Find out the forest canopy density in the Toranmal forest range in Nandurbar district.

Study Area:

The Toranmal Forest Range (TFR), a protected forest area in Nandurbar District, Maharashtra's western Satpura mountain, was chosen as the study area. With its high altitudinal placement of 1158 m MSL and trifunctional location between the three

states, the Toranmal plateau is a fundamental component of the Satpura Mountain and forms the cultural transition between Gujrat, Madhya Pradesh, and Maharashtra. on the Nandurbar District of North Maharashtra State, it is located on the western Satpura Mountain, a horst block between the Narmada Rift Valley on the north and Tapi on the south. A geographical area of 115.80 km^2 makes up the research area, which is located in the Nandurbar district's northern portion. In terms of latitude, it is located between 21° 47° and 21° 52° north and 74° 22° and 74° 30° east (Fig. 01). The study region includes two lakes (Yashwant & Lotus Lake), riverine forest, pockets of moist teak forest, agricultural fields, and mix dry deciduous woodland. The distribution of mixed species is also high in the forest. The southwest monsoon begins in mid-June and lasts until mid-October in the study area when the majority of the rainfall occurs. In the summer, the area's daily average temperature can exceed 30°C, while it drops to 6°C in the winter. The support of its tribal community, local catchment, species richness, and wildlife all depend on the Toranmal Forest Range (TFR). One of the best and most well-known hill resorts in North Maharashtra is located in the Dhadgaon Tahsil of the Nandurbar District.

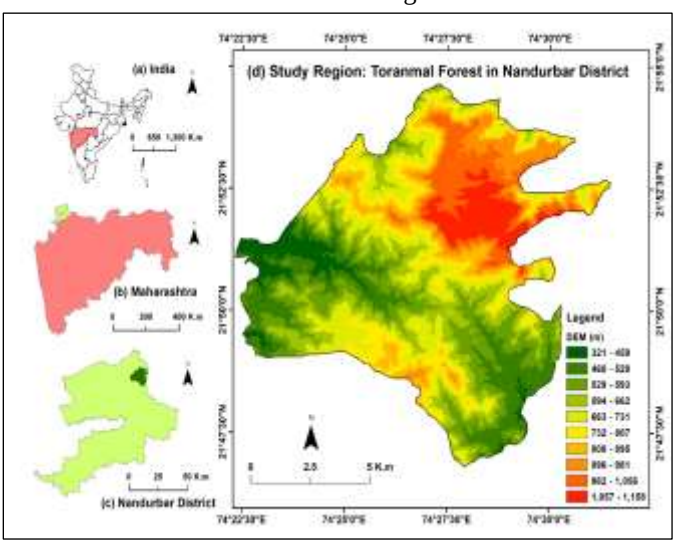


Fig.01, (a) India, (b) Maharashtra, (c) Nandurbar District, (d) Study region of Toranmal forest in Nandurbar District.

Data Collection and Research Methodology:

Dataset:

The density of forest cover was examined using a Landsat 8 satellite image. To extract four different indices, including NDVI, BSI, AVI, and SI, this satellite imagery was downloaded from the United States Geological Survey website (http://earthexplorer.usgs.gov/). The preparation of a Forest Canopy Density (FCD) map and the assignment of major weightage values for various classes of several themes come

first. According to research, the months of August, September, and October saw the greatest growth in the canopy of tropical monsoon deciduous forests. To obtain more accuracy, the precise (date and time) satellite imageries have been gathered.

To assess the current condition of the vegetation and develop the appropriate management plans for the future, an examination of vegetation cover density is necessary. In the current work, we employed a Landsat 8 satellite image (Path 139, Row 044, and Accusation Date 15 August 2020) to extract various metrics, including NDVI, BSI, AVI, and SI, as well as thematic layers. Field knowledge is used to determine the weights that are assigned to various thematic layers and their classes. Normalized weights were generated using Saaty's analytical hierarchy procedure and a pairwise comparison matrix. We used the Forest Canopy Density model to determine the spatial variation of forest cover and its quality after computing all of the indices and their corresponding weights in Arc GIS 10.4 software.

Image Pre Processing:

To evaluate the spatiotemporal expansion of the forest canopy as well as several forest parameters in the Toranmal forest range, Landsat 8 satellite pictures have been gathered from the USGS Earth Explorer website. To conduct scientific forest studies for the long-term conservation of forest resources, mostly monsoon and post-monsoon satellite imageries have been utilised. To calculate the area and improve data extraction, images are further transformed into Universe Transverse Mercator (UTM) projection from a geographic coordinate system. During the image-processing phase, the WGS 84 datum 43 North coordinate system has been taken into consideration. For improved depiction of satellite images and data collection, atmospheric correction has been made in Arc GIS Software 10.4. Meanwhile, Arc GIS 10.4 software has selected the right band subset and improved images appropriately.

Result: Four important spectral indices NDVI, BSI, AVI, and SI have been used to analyze the forest cover density.

Normalized Difference Vegetation Index (NDVI)

One of the most significant and beneficial techniques for estimating vegetation cover is the normalized difference vegetation index (NDVI). It is determined using the red-to-near-infrared band ratio of sunlight reflected off of plants. This equation was used by Rouse et al. (1974) to obtain the NDVI. It lies between one (positive one (+1) and one (negative one (-1)). Whereas -1 denotes a body of water 0 represents damp soil, and 0 to +1 symbolizes bare ground to +1 represents a well-grown forest.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$

where, accordingly, RED represents the surface reflectance of wavelengths in the visible range (0.6 m) and NIR represents the surface reflectance of wavelengths in the infrared

range (0.8 m). The NDVI is not an intrinsically physical number, but it is connected to the biomass, vegetation health, vegetation canopy, and fractional vegetation cover (Carlson and Ripley 1997). The slope line between RED-NIR space and the RED-NIR value of an image pixel is typically measured via NDVI. In 1974, Rouse et al. used NDVI for the first time.

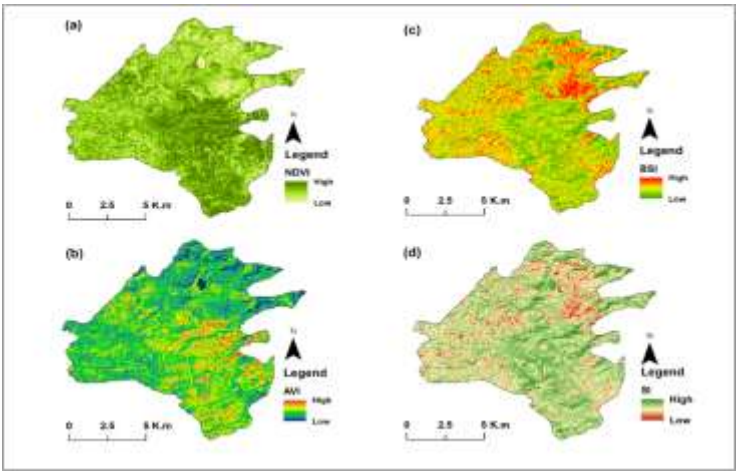


Fig.02, Spectral Indices of Forest Canopy Density, (a) NDVI, (b) AVI, (c) BSI and (d) SI.

The vegetative health state is indicated by the NDVI, which is essentially a spectral indicator. The NDVI value in the Toranmal forest range has been observed to range from - 0.07 to + 0.74 (Fig. 2a). Five additional classes have been created within the NDVI range. The threshold for each class is different. Higher and extremely high NDVI classes range from 0.58 to 0.74. The dense tropical deciduous forest is where high-NDVI values are found and predominate. These patches of dense forest are named here, including Godamba, Kelapani, and Goramba forests. Over the upper and middle courses of the research region, moderate NDVI value 0.40 to 0.50) is concentrated. From the ground, it can be seen that agricultural land and scrubs make up the majority of the NDVI medium-value area. While dominating sections display barren terrain and agricultural land, low-NDVI values are primarily restricted to the less vegetated portions of the Toranmal forest.

Advanced Vegetation Index (AVI):

Similar to NDVI, the Advanced Vegetation Index is a significant spectral reflectance index that allows us to extract vegetation conditions from a multi-spectral image. Red and infrared bands, two separate types of spectral bands, are employed to categorize the vegetation conditions using spectral reflectance values (Fig. 2b). In order to resolve the high canopy areas, AVI is more sensitive than NDVI. The difference

between NDVI and AVI, which is improved using a power degree, is negligibly small (Roy et al. 1996). The vegetation foliage activity is also recovered using the AVI index, and there is a slight variation between NDVI and AVI (Anonymous 1993)

$$\mathrm{AVI} = [(\mathrm{NIR} + 1(1 - \mathrm{Red}) \times (\mathrm{NIR} - \mathrm{Red})]^{1/3}$$

Similar to NDVI, AVI is also a spectral reflectance index. But there isn't much of a distinction between AVI and NDVI. The AVI value range ranges from 0.00 to 0.054 (Fig. 2b). Due to a higher concentration of dense deciduous forest, the southern portion of the Toranmal forest range has a high and very high advanced vegetation index.

Bare Soil Index (BSI):

When the area of land is described as being bare, it signifies that no human activity has taken place there during the specified geological time. The bare soil index, also known as a spectral reflectance index, depicts the state of the soil or land in a region (Fig. 02c). It has primarily been utilized as a farmland indicator. Primary bare land contains no traces of human habitation, while secondary bare land has varying degrees of anthropogenic footprints (Pal et al. 2018).

The degree of bareness has been determined using four different spectral bands, including blue, red, near-infrared, and short-wave infrared. The near-infrared and blue bands have been utilized to represent the vegetation condition, while the short-wave infrared and red bands have been used to indicate the mineral composition of the soil. The amount of forest canopy cover over a certain time period is also indirectly reflected by the bare soil index (Rikimaru and Miyatake 1997). The following equation is used to determine the bareness soil index (BSI):

$$\mathrm{BSI} = \frac{(\mathrm{Band\ 6} + \mathrm{Band\ 4}) - (\mathrm{Band\ 5} - \mathrm{Band\ 2})}{(\mathrm{Band\ 6} + \mathrm{Band\ 4}) + (\mathrm{Band\ 5} + \mathrm{Band\ 2})}$$

where Band2 is the blue band's reflectance value, Band4 is the red band's reflectance value, Band5 is the infrared band's reflectance value, and Band6 is the shortwave infrared band's reflectance value.

A spectral reflectance index is called BSI. According to Fig. 2c, the soil's bareness values range from -0.43 to +0.14. Five additional classes have been created from the entire basin area; each class has its own threshold value that distinguishes it from the others. The water body, river channel, and exposed land in the Toranmal forest range show high and very high bareness that is dispersed over middle and isolated areas of the research area's northern region. Forests and agricultural terrain have low to very low BSI indices.

Shadow Index (SI):

A crucial spectral index that gives crucial details on the coverage of the forest canopy is the canopy shadow index. The overall amount of canopy cover reflectance is examined by the SI index. While a low SI value suggests an open forest or relatively

fewer forested areas, a high SI value denotes a mature or dense forest (Fig. 2d). While the SI index also calibrates the total reflectance through the forest canopy, the FCD model is utilized to determine the real canopy cover (Huemmrich, 1996)

$$SI = [(1 - \text{Red}) \times (1 - \text{Green}) \times (1 - \text{Blue})]^{1/3}$$

The canopy shadow effects on spectral reflectance curves are measured using the spectral reflectance index known as the Shadow Index. Compared to fresh forest areas, mature forests have greater SI values. In the Toranmal forest range, it has been noted that the SI value ranges from 0.19 to 0.26 (Fig. 2b). There are five different SI classifications for the basin. Every class has its own cutoff. Due to the dominance of tropical deciduous forests, extremely high SI values of 0.26 are restricted to the middle and lower areas. A very low SI value (0.19) has primarily been limited to exposed land areas, water bodies, and river channels.

Forest Canopy Density Model:

The Toranmal Forest Range's (FTR) Forest Canopy Density Model (FCDM) was created by combining four separate indices, including the Advanced Vegetation Index (AVI), Bare Soil Index (BSI), and Shadow Index (SI). To obtain results with great precision, the Weightage Overlay Analysis approach has been used (Fig. 3). Weights are assigned to various themes and classes of themes based on their relative importance (Tables 01 and 02). The five classes were created using FCD values that range from extremely low to extremely high. Due to the favourable climatic circumstances for their growth inside the designated study area, the middle course and the lower middle courses have high and extremely high forest cover, respectively. The upper section of the basin includes an undulating plateau with scattered open woodland and a medium to low canopy density.

Table.01. Assignment and Normalization of class weight for different spectral indices

Spectral Indices	Class	Assigned weight	Normalized weight
Normalized Differences Vegetation Index (NDVI)	Very high	5	0.33
	High	4	0.27
	Moderate	3	0.20
	Low	2	0.13
	Very low	1	0.07
Advanced Vegetation Index (AVI)	Very high	5	0.33
	High	4	0.27
	Moderate	3	0.20
	Low	2	0.13
	Very low	1	0.07

Bare Soil Index (BSI)	Very high	1	0.07
	High	2	0.13
	Moderate	3	0.20
	Low	4	0.27
	Very low	5	0.33
Shadow Index (SI)	Very high	5	0.33
	High	4	0.27
	Moderate	3	0.20
	Low	2	0.13
	Very low	1	0.07

Source: Computed by another in Arc GIS 10.4 Software.

In the Toranmal Forest Range (TFR) area, 0.75, 4.84, 22.38, 38.90, and 33.14% of the geographical areas, respectively, are covered in very low canopy, low canopy density, medium canopy density, high canopy density, and very high canopy density of forest (Table.03). Typically, tropical deciduous forests with teak, Sal, Jackfruit, Arjun, and Palash trees surround high canopy density areas. A medium to low FCD value is seen in the agricultural fields and bare terrain. To calculate the canopy, cover of the forest and the health of the forest, this model is extremely logical and scientific (Tables 01, 02).

Table 02. Normalization Procedure of Assigned Weight

Spectral Indices	Normalized Differences Vegetation Index (NDVI)	Advanced Vegetation Index (AVI)	Bare Soil Index (BSI)	Shadow Index (SI)	Geometric Mean	Normalized weight
Normalized Differences Vegetation Index (NDVI)	5/5	5/4	5/3	5/2	1.51	0.36
Advanced Vegetation Index (AVI)	4/5	4/4	4/3	4/2	1.21	0.29
Bare Soil Index (BSI)	3/5	3/4	3/3	3/2	0.91	0.21
Shadow Index (SI)	2/5	2/4	2/3	2/2	0.61	0.14

Source: Computed by another in Arc GIS 10.4 Software

A crucial tool for calculating the density of forests in a given area is the forest canopy density model (Sahana et al. 2015). The amount of deforested or degraded forest areas can be simply determined by using this approach. Finally, all the indices described above are merged to create the final product for the Toranmal woodland Range of Nandurbar District (Fig. 03). The FCD map was created utilizing weightage overlay analysis techniques using Arc GIS (10.4) software.

Table 03. Forest canopy density model of Toranmal Forest in Nandurbar District

Sr. No	Forest canopy density class	Area in sq K.m	Area in %
1	Very low	0.870	0.75
2	Low	5.600	4.84
3	Moderate	25.916	22.38
4	High	45.047	38.90
5	Very high	38.376	33.14

Source: Computed by another in Arc GIS 10.4 Software.

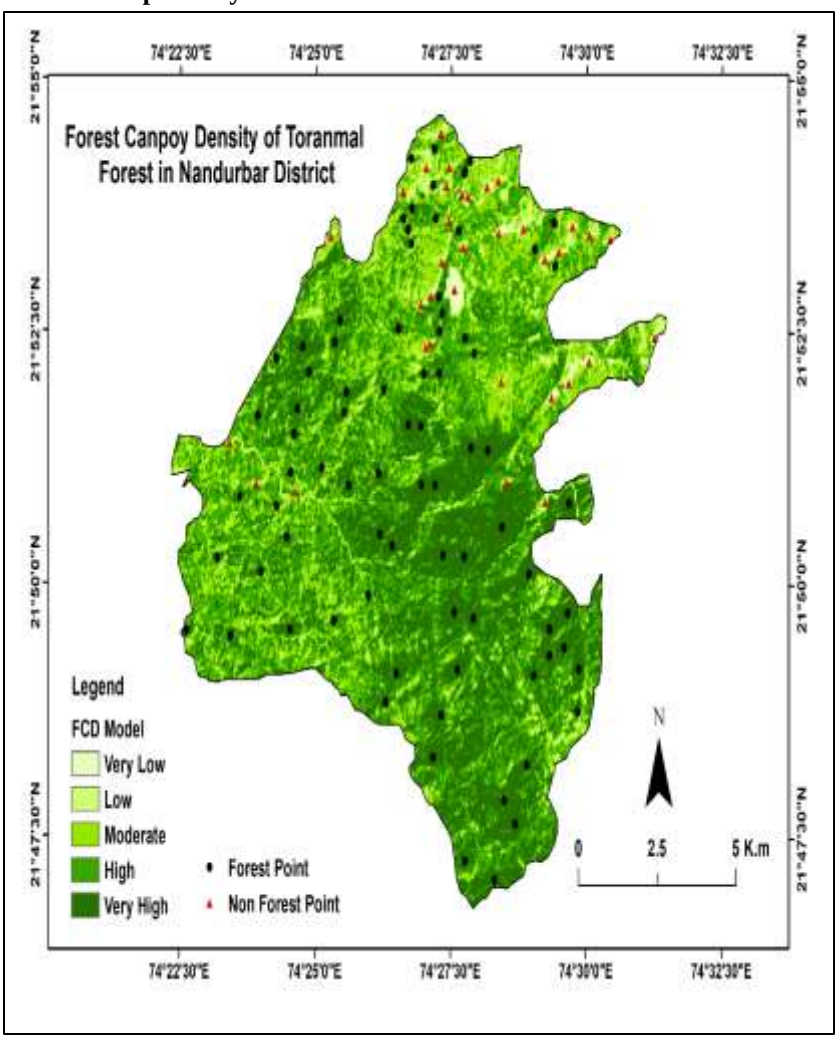


Fig.03 Forest Canopy Density model of Toranmal Forest.

Validation of FCD Model:

The Weighted Over Analysis (WOA) output was confirmed by the study's Forest canopy density using the Google Earth map and the Ground truth point map using ROC-AUC evaluations. By comparing the Forest Canopy Density (FCD) map with the Forest and non-forest points using the Arc SDM tool in the Arc GIS10.4 program, the ROC-AUC has been carried out. The ROC curves and AUC diagrams for the FCD model are shown in Fig. 03 and 04. The FCD model's accuracy rate was shown by the AUC, which can be divided into four groups: excellent (> 0.9), accepted (0.8-0.9), good (0.7-0.8), and considerable (0.5-0.7). The research found that the WOA technique's observed accuracy is 0.97%. As a result, the model effectively generates the Forest Canopy Cover (FCD) model map, which is regarded as an excellent outcome on the satisfaction scale.

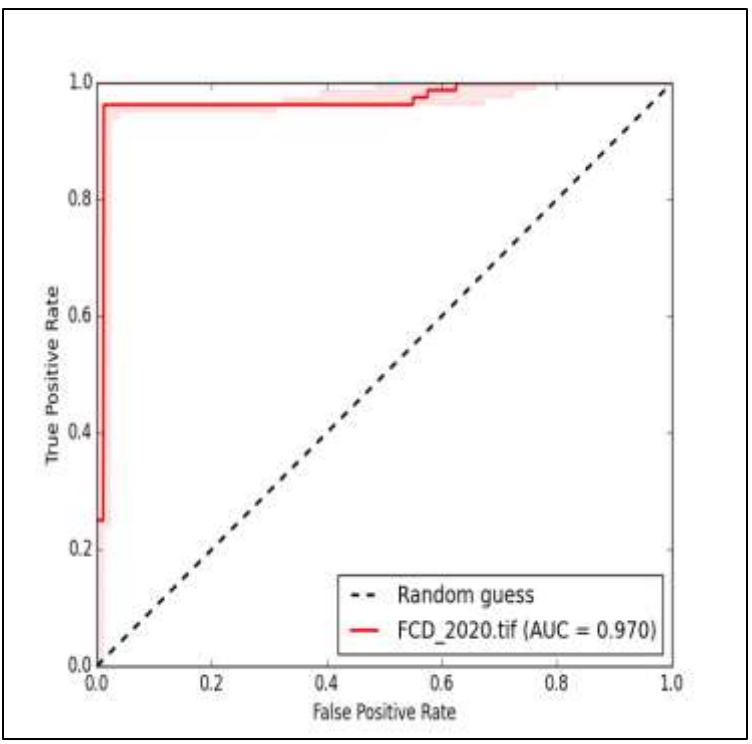


Fig.04: ROC- AUC Curve of Forest Canopy Density (FCD) in Toranmal Forest Range.

Conclusion:

This geospatial application-based study focuses on the assessment of the current canopy density (2020) in the Toranmal forest range by the included of four spectral indices, including the Normalized Difference Vegetation Index, Advanced Vegetation

Index, Bare soil Index (BSI), and Shadow Index. While greater NDVI, AVI, and SI values show a higher forest canopy density, higher BSI values show a lower forest cover. Due to the presence of several protected and reserve forests, including Kelapani, Goramba, Jugani, and Godamba, a few core pockets as well as the South and core part of the Toranmal forest range (TFR) indicate high FCD values. The upper part of the Toranmal forest range (TFR) also has scattered forest ranges, including those at Yashwant Lake, Lotas Lake, Sitakhai Point, and Khadki Point.

People's ambition to grow various cash crops, including cotton, oil seeds, and pulses, as well as tribal settlement in recent years, has increased the high rate of deforestation around regional growth centres. In tropical and subtropical forest environments, significant anthropogenic stress can change the scenario of pristine forest cover over time. Even though the models stated above have been effectively used in various parts of the world, more research and development is needed to improve their accuracy. Before formulating policies for the sustainable conservation of forest resources as well as for balanced regional growth and development, administrators and policy makers should take these research findings into consideration.

References:

1. Rouse JW, Haas RH, Scheel JA, Deering DW (1974) Monitoring vegetation systems in the great plains with ERTS. In: Proceedings, 3rd earth resource technology satellite (ERTS) symposium, pp. 48–62. https://ntrs.nasa.gov/citations/19740022614.
2. Roy PS, Sharma KP, Jain A (1996) Stratification of density in dry deciduous forest using satellite remote sensing digital data— an approach based on spectral indices, pp 723–734. https://doi. org/10.1007/BF02703148.
3. Anonymous (1993) Rehabilitation of logged over forests in Asia/Pacific region. Final Report of Sub Project II International Tropical Timber Organization—Japan Overseas Forestry Consultants Association, pp 1–78.
4. Pal SC, Chakrabortty R, Malik S et al (2018) Application of forest canopy density model for forest cover mapping using LISS-IV satellite data: a case study of Sali watershed, West Bengal. Model Earth Syst Environ 4:853–865. https://doi.org/10.1007/s4080 8-018-0445-x.
5. Huemmrich KF (1996) Effects of shadows on vegetation indices. In: IGARSS international geoscience and remote sensing symposium, Lincoln, NE, USA, vol 4, p 23722374. https://doi.org/10.1109/ IGARSS.1996.516990.
6. Sahana M, Sajjad H, Ahmed R (2015) Assessing spatio-temporal health of forest cover using forest canopy density model and forest fragmentation approach in Sundarban reserve forest, India. Model Earth Syst Environ 1(4):49. https://doi.org/10.1007/s4080 8-015-0043-0.

7. Benítez-Malvido, J., & Martínez-Ramos, M. (2003). Impact of forest fragmentation on understory plant species richness in Amazonia. Conservation Biology, 17(2), 389–400. https://doi.org/10.1046/j.1523-1739.2003.01120.x.
8. Bera Biswajit and Bhattacharjee Sumana (2020). Estimation of forest canopy cover and forest fragmentation mapping using landsate satellite data of Silabati river basin (India), journal of cartography and geographic information 70 (70), 181-197.
9. Coppin, P. R., & Bauer, M. E. (1994). Processing of Multitemporal Landsat TM Imagery to Optimize Extraction of Forest Cover Change Features. In IEEE Transactions on Geoscience and Remote Sensing (Vol. 32, Issue 4).
10. uang, C., Davis, L. S., & Townshend, J. R. G. (2002). An assessment of support vector machines for land cover classification. International Journal of Remote Sensing, 23(4), 725–749. https://doi.org/10.1080/01431160110040323.
11. Kiran. S., & Kaur Ramandeep, (2011). Economic valuation of forest soils. In Current Science (Vol. 100, Issue 3). G. Sandhya Kiran* and Malhi Ramandeep Kaur M.
12. Jaybhay. R., and Badhe. Y., (2022). Forest fragmentation analysis in part of Kalsubai Harishchandragad wildlife sanctuary of northern western Ghats, Maharashtra, Indian journal of ecology, 49 (2), 552-557.
13. Pyngrope. O.R and Singh. S.K(2021). Investigating forest fragmentation through earth observation dataset and metric analysis in the tropical rainforest area, journal of SN Applied sciences, 3 (750), 78-84.
14. Mehta A., and Rakholia.S. (2022). Assessment of forest fragmentation in Grater Gir landscape area, using geospatial techniques, journal of Geomatics. 16(50), 146-151.
15. Zhang, Y., Sharma, S., Bista, M., & Li, M. (2022). Characterizing changes in land cover and forest fragmentation from multitemporal Landsat observations (1993-2018) in the Dhorpatan Hunting Reserve, Nepal. Journal of Forestry Research, 33(1), 159–170. https://doi.org/10.1007/s11676-021-01325-9.

Urban Land use Land cover change detection in Phaltan City of Satara District Maharashtra using Geospatial Technology

Prakash S. Shinde
Ph.D. Research Scholar, Shivaji University, Kolhapur 416004, Maharashtra, India.
E-mail: sprakash.gisrs@gmail.com
Namdev V. Telore
Professor, Department of Geography, Raja Shripatrao Bhagawantrao Mahavidyalaya, Aundh, Satara 415510, Maharashtra, India.
E-mail: nvtelore@gmail.com
Rahul S. Chaure
Assistant Professor, Department of Geography, Mudhoji College, Phaltan, Satara 415523 Maharashtra, India.
E-mail: rahulschaure@gmail.com

Article DOI Link: https://zenodo.org/records/10559048
DOI: 10.5281/zenodo.10559048

Abstract:

Over the past three decades, Phaltan City has undergone significant changes in land use and land cover (LULC). Employing geospatial technology, this study aimed to detect and quantify these changes by classifying the city into four major categories: Waterbody, Agriculture, Barren land, and built-up areas. Utilizing a supervised classification method, LULC types were mapped, and classification accuracy was assessed using the kappa coefficient and total accuracy. A post-classification comparison approach was employed on classified images to identify LULC changes between 1991 and 2023. The results reveal a notable surge in urban growth over the last two decades, leading to a reduction in barren land surrounding the city. The study demonstrates a 7.48% increase in built-up land, while the area of barren land experienced a significant decrease by 20.47%, diminishing to 10.24%. Various factors contributed to these LULC changes, including urbanization, population growth, social and economic development, and climatic variations. This research sheds light on the dynamics of LULC changes and their driving forces, providing valuable insights for Phaltan City authorities to formulate sustainable development plans. The findings underscore the impact of increased population growth and rapid urban migration, emphasizing the need for proactive measures to balance urban expansion with the preservation of green spaces and vegetation cover.

Keywords: LULC, Supervised classification, Geospatial Technology, Urban sprawl.

Introduction:

Land use encompasses activities conducted on and around the land, often not

readily discernible through imagery, whereas land cover refers to a region's vegetation and artificial structures. Satellite data stands as a reliable source, offering accurate and real-time insights into the spatial dynamics of the land surface (Roy et al., 2008).

Remote sensing and Geographic Information Systems (GIS) present swift and efficient means to classify and map land use/land cover changes across temporal and spatial dimensions. The analytical prowess of GIS in integrating and processing temporal and spatial data facilitates the quantification of land use changes. The intersection of natural and human influences on environmental changes is crucially linked to land use and land cover (LULC) change. Digital classification techniques, particularly through the stratification approach with limited ground truth, prove effective for mapping broad land cover categories and their spatial distributions. Remote sensing data, with its application in land cover classification, stands out as the most effective measure, employing methods like supervised and unsupervised digital image processing.

Observing spatial and temporal changes on the Earth's surface has become reliant on remotely sensed satellite images capable of capturing shifts caused by natural processes and human activities. The investigation of land use and land cover change seeks to elucidate where changes occur, what types of land cover are evolving, the rate of change, and the driving forces behind such alterations (Loveland et al., 2006). Additionally, it is imperative to forecast future land use and cover patterns through simulation modeling, fitting evaluative systems to historical examples and extrapolating patterns into the future to understand when, where, and why LULC changes occur (Brown et al., 2000; Telore and Unde, 2018). Landsat imagery, available since 1972, serves as a pivotal source for optical remote sensing data related to LULC monitoring. Landsat TM/ETM+/OLI data, with a spatial resolution of 15m-60m, is instrumental in defining environmental characteristics at a medium scale.

Recent studies, such as one assessing the spatiotemporal dynamics of LULC in the peri-urban area of the Arshaly district bordering the capital of the Republic of Kazakhstan (Alipbeki et al., 2020), have demonstrated the effectiveness of Landsat imagery in detecting LULC changes. Similarly, investigations in Mandalay City (Thein and Htwe, 2023) showcased substantial LULC alterations linked to economic factors and urbanization trends. The study at hand focuses on the monitoring of the study region, employing remote sensing data to evaluate barren land, agriculture, built-up areas, and water bodies. Utilizing a post-classification method, quantitative results of LULC changes for 1991, 2001, 2011, and 2023 were computed.

Objectives: The primary objectives of this study are as follows:

1. To conduct a comprehensive analysis of land use and land cover changes in the study rea over a specified period.
2. To identify and characterize alterations in land use and land cover patterns within the study area during the mentioned timeframe.

Study Area:

Phaltan City is located in Satara District (Maharashtra). The study area extension is between $17^0$40’ to $18^0$15’N. latitude and $74^0$10’ to $74^0$40’ E. longitude. The study area was found in SOI Toposheet 47 K/5 (1:50000 scale). The Banganga is a seasonal river that flows in the middle part of the city. The elevation of Phaltan City is 568 meters (above Mean Sea Level). Inland weather characterizes Phaltan's climate in Maharashtra. The temperature ranges from 15 to 45 °C. Compared to nearby inland communities, Phaltan experiences a hotter and drier summer. Maximum temperatures exceed 40 °C every summer and typically range between 38–45 °C. Lows this time of year range from 25 to 28 °C. The city has been classified as a drought-prone area by the government since it experiences less rainfall from June to September. Occasionally, Phaltan experiences dry spells during the monsoon season. In Phaltan, winter lasts from November to February. Compared to other Maharashtrian cities like Nashik and Pune, the winters are noticeably warmer. The lowest temperatures range from 14–16 °C (57–61 °F), while the highest are in the range of 29–32 °C (84–90 °F). Humidity is low in this season. Phaltan crosses a drought-prone area; a dry area is present to the south and southwest of Phaltan, and a dry area begins. Water for drinking and irrigation is provided by the Nira right bank canal.

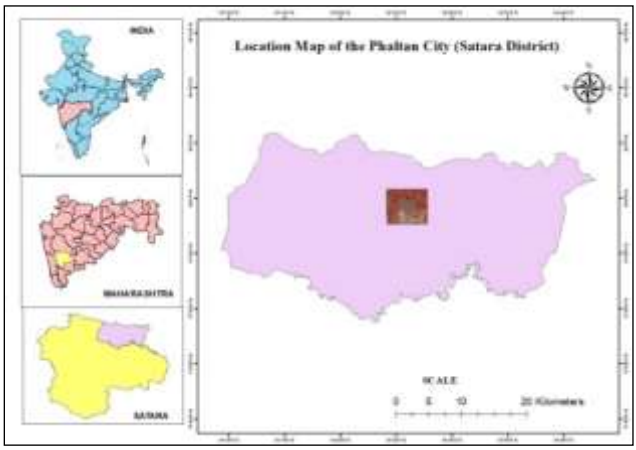


Figure 1: Location Map

Materials And Methodology:

The current study unfolded through a structured sequence of six steps, encompassing the identification of the study area, data collection, image pre-processing, supervised classification, data accuracy analysis, and change detection. To assess changes in land use and land cover, a crucial prerequisite is the availability of data from at least two distinct time periods for comparative analysis. For this study, Landsat4-5 Thematic Mapper (TM) data and Landsat 8 Operational Land Imager (OLI) data in

Geotiff (Level-2) format were acquired from the USGS Earth Explorer (http://earthexplorer.usgs.gov/) (refer to Table 1). The obtained images underwent rectification and were assigned UTM-Zone 43N, WGS-84 datum coordinates. Image processing and statistical spatial analysis were carried out using ArcGIS 10.4.

Supervised classification was employed as the methodology for detecting changes in land use and land cover patterns within the study area. The Maximum Likelihood Classifier (MLC) operated on the principle that pixels of unknown class membership are assigned to classes with the highest likelihood of membership. This decision rule, derived from information contained in a set of signature files, facilitated the classification of remotely sensed data.

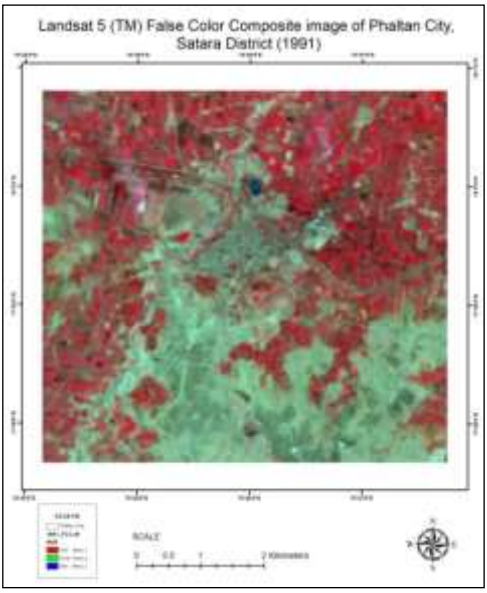
Landsat Data:

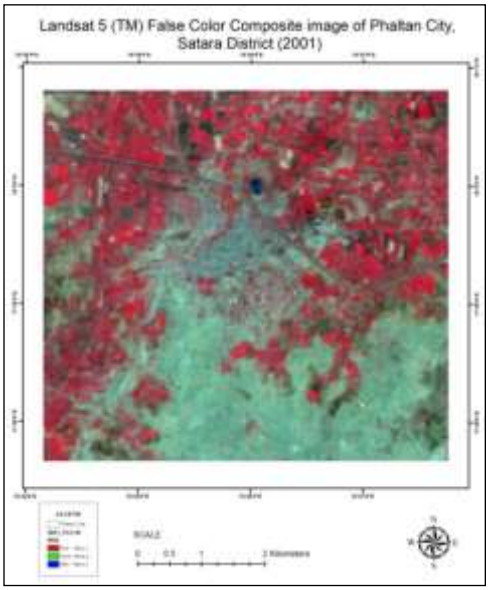
LULC classification relied on four Landsat data scenes, as outlined in Table 1. The Landsat data exhibits a swath width of 185 km with a 30-meter resolution and a revisit time at 16-day intervals.

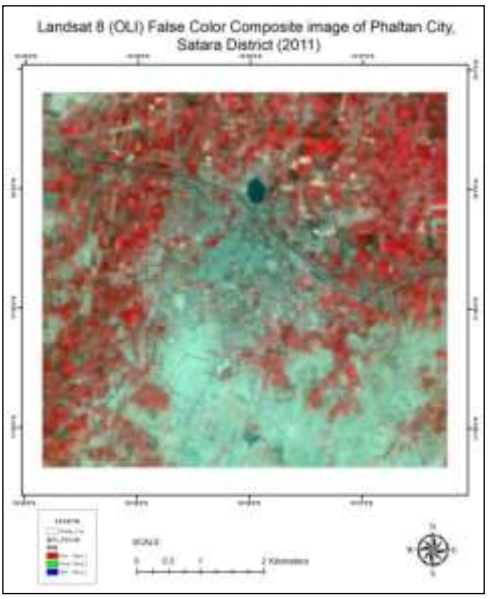
Scene No.	Year	Series	Sensor	Date of Acquisition	Path No.	Row No.	Band Numbers
1	1991	Landsat 5	TM	1991-02-01	147	047	Band 1-7
2	2001	Landsat 5	TM	2001-01-11	147	048	Band 1-7
3	2011	Landsat 8	OLI	2011-01-31	147	048	Band 1-11
4	2023	Landsat 8	OLI	2023-01-24	147	047	Band 1-11

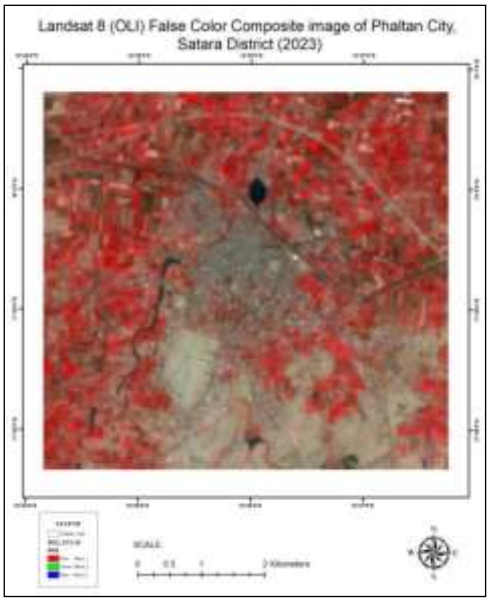
Table 1. Landsat data

Figure 2: False Color Composite (FCC) Landsat image of the study area.









ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Methods:

This paper employs a supervised classification method for the classification of remote sensing images, relying on spectral and texture features. The classification involves categorizing LULC types into five classes using the maximum likelihood method, encompassing settlement areas, agriculture/vegetation areas, barren land, and water bodies. The collection of training and validation samples is facilitated by a visual interpreter. To ensure the reliability of the classification results, accuracy assessment is a crucial phase. An error matrix is utilized to articulate a comparison array that highlights the pixel numbers for a specific category compared to the ground-tested pixel numbers for that category. The accuracy of a classification is determined by various indicators, including overall accuracy, product accuracy, customer accuracy, and Kappa statistics, all derived from the error matrix for each classification result.

Subsequently, the change detection procedure is implemented based on the classification results at three distinct time steps, leading to the formulation of conclusions. The utilization of ArcGIS 10.4 facilitates the export of classification maps and the computation of change statistics.

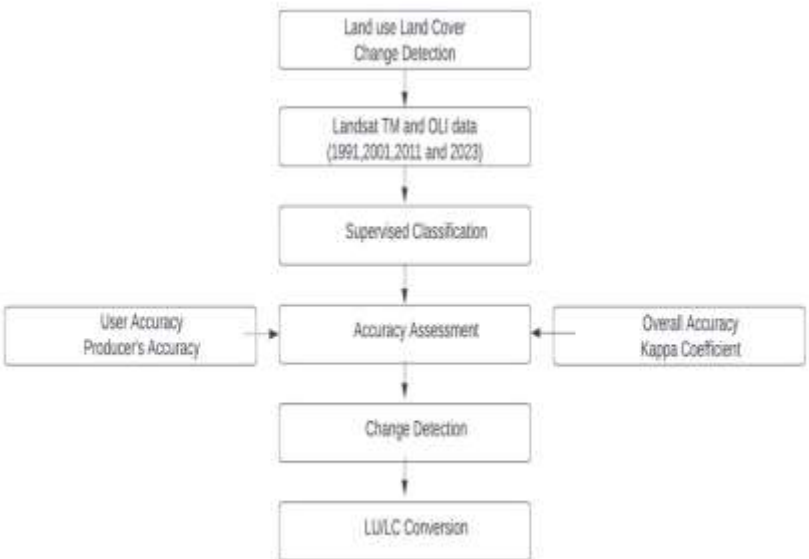


Figure 2: Methodological Flow-chart.

Results And Discussion:

The classification results of 1991, 2001, 2014, and 2023 are shown in Figures 2 and 3. Random sampling is used to evaluate the accuracy of each classification image. The accuracy assessment results are calculated and analyzed (See Table 3).

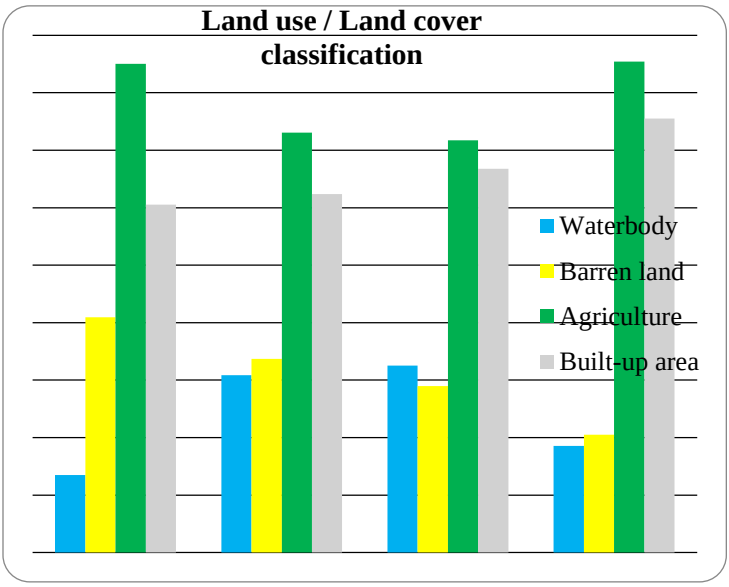


Figure 3. The land use and land cover classification area in % (1991, 2001, 2011 and 2023).

LU/LC Class	LU / LC Area in %			
	1991	**2001**	**2011**	**2023**
Waterbody	6.73	15.43	16.27	9.29
Barren land	20.47	16.86	14.49	10.24
Agriculture	42.52	36.52	35.85	42.72
Built-up area	30.27	31.19	33.40	37.75
Total	100	100	100	100

Table 2. Summary of Landsat classification area in percentage.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

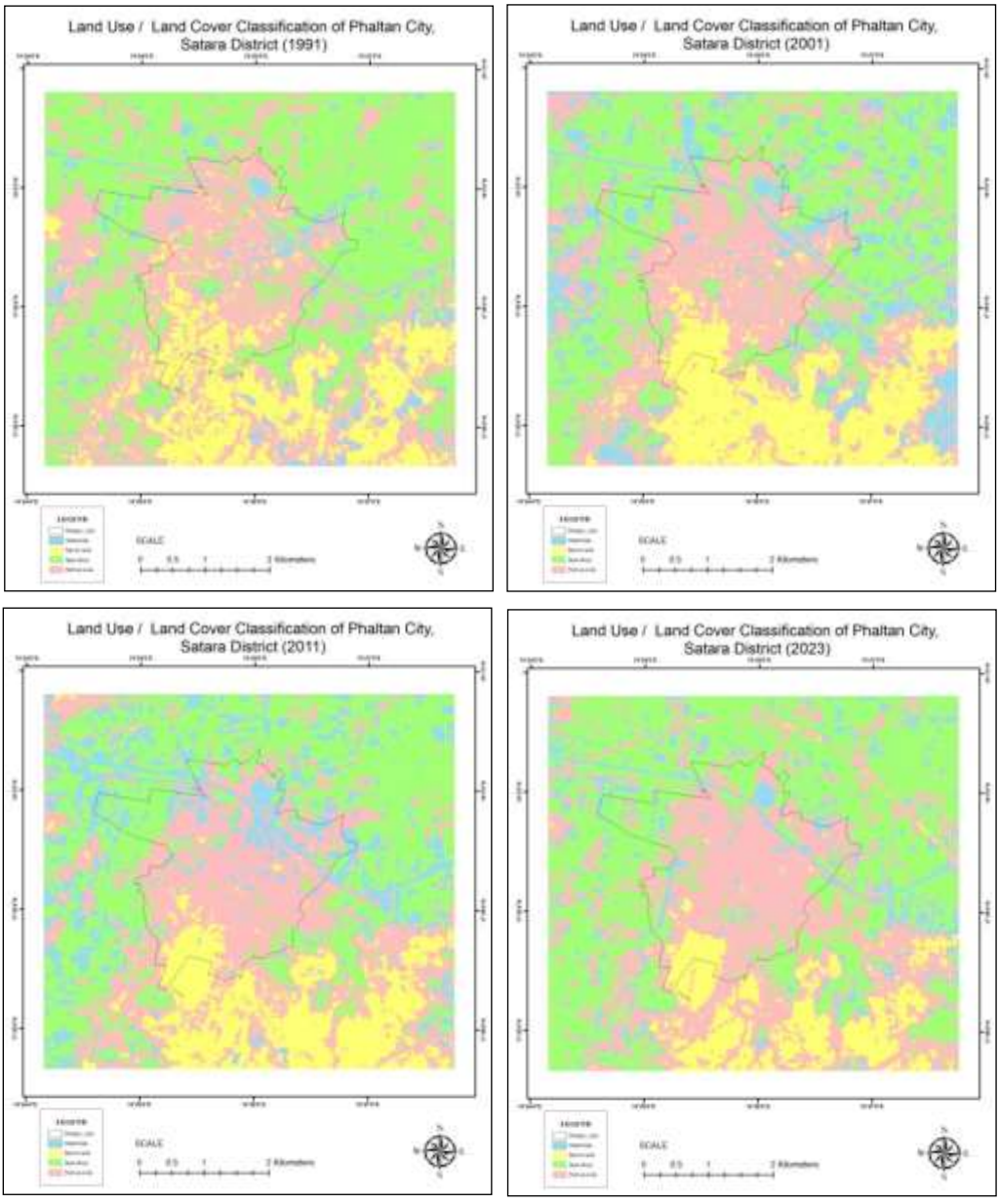

Land Use / Land Cover Classification of Phaltan City, Satara District (1991)
Land Use / Land Cover Classification of Phaltan City, Satara District (2001)
Land Use / Land Cover Classification of Phaltan City, Satara District (2011)
Land Use / Land Cover Classification of Phaltan City, Satara District (2023)

Figure 4. The land use and land cover classification (1991, 2001, 2011, and 2023).

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

The LULC changes in the Phaltan urban are illustrated in Figure 3. The areas of built up have been increasing since 1991, whereas areas of barren land have been decreasing. The area of the water body changes over time due to monsoon types of rainfall in the study area and the canal irrigation system in the study area. Corresponding statistic values are listed in Table 2.

Year	Classified	Waterbody	Agriculture	Barren-land	Built-up area	Total	Correct sampled
1991	Waterbody	20	1	0	6	27	20
	Agriculture	1	102	0	1	104	93
	Barren land	0	0	12	0	12	12
	Built-up areas	2	2	0	61	65	61
	Total	**23**	**105**	**12**	**68**	**208**	**186**
2001	Waterbody	26	2	0	3	31	25
	Agriculture	0	105	0	2	107	100
	Barren land	0	0	18	0	18	17
	Built-up areas	0	0	0	101	101	92
	Total	**26**	**107**	**18**	**106**	**257**	**234**
2011	Waterbody	27	2	3	3	35	26
	Agriculture	1	100	0	1	102	96
	Barren land	0	0	30	0	30	52
	Built-up areas	2	6	26	84	118	81
	Total	**30**	**108**	**59**	**88**	**285**	**255**
2023	Waterbody	33	2	1	2	38	34
	Agriculture	1	80	1	1	83	82
	Barren land	0	0	30	2	32	58
	Built-up areas	2	6	30	60	98	60
	Total	**36**	**88**	**62**	**65**	**251**	**230**

Table 3. Theoretical error matrix of LULC classification (1991)

The analysis reveals a notable increase in the built-up area, rising from 30.27% in 1991 to 37.75% in 2023, reflecting a 7.48% expansion. Conversely, there is a substantial transformation in the area of barren land surrounding the city, decreasing from 20.47% to 10.24%. This change is attributed to increased settlements in the study area, driven by industrial development and urbanization. The urban growth is expanding into the adjoining suburban regions of Kolki, Jadhavwadi, Vinchurni, and Thakuri

village areas. The classification accuracy for the different years is reported as follows: 89% for 1991, 90.99% for 2001, 89.01% for 2014, and 91.63% for 2023 (refer to Table 3).

The Producer's accuracy gauges errors of omission, assessing how accurately real-world land cover types are classified. Meanwhile, the User's accuracy measures errors of commission, indicating the likelihood of a classified pixel matching the land cover type of its corresponding real-world location. The assessment of Producer and User accuracy, along with the Kappa coefficient, is detailed in Table 4.

Year	Class Name	Reference Total	Classified Total	No. of Correct sampled	Overall accuracy	Kappa Coefficient
1991	Waterbody	23	27	20	87%	0.74
	Agriculture	105	104	93	89%	0.89
	Barren land	12	12	12	100%	1
	Built-up	68	88	61	90%	0.69
	Total	**208**	**208**	**186**	**89%**	**Overall = 0.89**
2001	Waterbody	26	31	25	96%	0.8
	Agriculture	107	107	100	93%	0.93
	Barren land	18	18	17	94%	0.94
	Built-up	106	101	92	87%	0.91
	Total	**257**	**257**	**234**	**91%**	**Overall = 0.91**
2011	Waterbody	30	35	26	87%	0.74
	Agriculture	108	102	96	89%	0.94
	Barren land	59	30	52	88%	0.88
	Built-up	88	118	81	92%	0.68
	Total	**285**	**285**	**255**	**89%**	**Overall = 0.89**
2023	Waterbody	36	38	34	94%	0.89
	Agriculture	88	83	82	93%	0.93
	Barren land	62	32	58	94%	0.94
	Built-up	65	98	60	92%	0.87
	Total	**251**	**251**	**230**	**92%**	**Overall = 0.90**

Table 4. Classification Accuracy Assessment Report (1991,2001, 2011, and 2023).

Conclusion:

Drawing upon the classification results and the dynamic analysis spanning from 1991 to 2023, several noteworthy conclusions emerge. The values acquired for the kappa coefficient and total accuracy met the stipulated requirements for effective categorization. The study's outcomes underscore a significant alteration in Land Use and Land Cover (LULC) throughout the 32 year investigation period, particularly evident in the reduction of barren land areas attributed to the burgeoning built-up area in the study zone. Over the last three decades, there has been a consistent decline in barren land, paralleled by an expansion of settlement areas, reflecting the increasing population in the region. Additionally, improvements in the water body area were observed, influenced by the implementation of diverse soil and water conservation structures, a result of various government schemes and programs in the study area.

Photo Plates Waterbody:

Agriculture/Vegetation:

Barren land:

Built up area / Settlement:

Figure 5. The land use and land cover photo plates of the study area.

References:

1. Alipbeki, O., Onggarbek, Chaimgul, A., Sterenharz, A., Toleubekova, Z., Aliyev, M., Mineyev, N., & Amangaliyev, K. (2020). A Spatiotemporal Assessment of Land Use and Land Cover Changes in Peri-Urban Areas: A Case Study of Arshaly District, Kazakhstan. Sustainability, 12, 1556. doi: 10.3390/su12041556.
2. Brown, D. G., Pijanowski, B. C., & Duh, J. D. (2000). Modeling the relationships between land use and land cover on private lands in the Upper Midwest, USA. Journal of Environmental Management, 59(4), 247–263. https://doi.org/10.1006/jema.2000.0369.
3. Goldblatt, R., Stuhlmacher, M. F., Tellman, B., Clinton, N., Hanson, G., Georgescu, M., ... & Cheng, W. (2018). Using Landsat and nighttime lights for supervised pixel-

based image classification of urban land cover. Remote Sensing of Environment, 205, 253-275. https://doi.org/10.1016/j.rse.2017.11.026.

4. Jia, K., Wei, X., Gu, X., Yao, Y., Xie, X., & Li, B. (2014). Land cover classification using Landsat 8 Operational Land Imager data in Beijing, China. Geocarto International, 29(8), 941–951. https://doi.org/10.1080/10106049.2014.894586.
5. Kumar, R., & Acharya, P. (2016). Flood hazard and risk assessment of 2014 floods in Kashmir valley: A spacebased multisensor approach. Natural Hazards, 84(1), 437–464. https://doi.org/10.1007/s11069-016-2428-4.
6. Loveland, T. R., & Acevedo, W. (2006). Land cover change in the Eastern United States. US Geological Survey. Retrieved from https://landcovertrends.usgs.gov/east/regionalSummary.html.
7. Naikoo, M. W., Rihan, M., Ishtiaque, M., & Shahfahad. (2020). Analyses of land use land cover (LULC) change and built-up expansion in the suburb of a metropolitan city: Spatio-temporal analysis of Delhi NCR using Landsat datasets. Journal of Urban Management, 9(3), 347-359. https://doi.org/10.1016/j.jum.2020.05.004.
8. NRSA. (1990). Manual of nationwide land use/land cover mapping using digital techniques, part-II. RRSSC, Nagpur, Dept. of Space, Govt. of India.
9. Roy, P. S., & Giriraj, A. (2008). Land Use and Land Cover Analysis in Indian Context. Journal of Applied Sciences, 8, 1346-1353. DOI: 10.3923/jas.2008.1346.1353.
10. Telore N.V. and Unde M.G. (2018). Land Use and Land Cover Analysis of the Semi Arid Yerla River Basin, Maharashtra using Landsat Data. Electronic International Interdisciplinary Research J (EIIRJ). 'Emerging Technologies in Remote Sensing & GIS - Its Development & Applications'. VII (XIII), Feb. 2018. 119-126. ISSN - 2277-8721 UGC Approved: 48833 http://www.aarhat.com/eiirj/wp-content/uploads/2018/08/Final-Book.compressed.pdf
11. Thapa, R., & Murayama, Y. (2009). Urban mapping, accuracy, & image classification: A comparison of multiple approaches in Tsukuba City, Japan. Applied Geography, 29, 135-144. 10.1016/j.apgeog.2008.08.001.
12. Thein, A. M., & Htwe, A. N. (2023). Based on Principal Component Analysis of Land Use Land Cover Change Detection Using Landsat Satellite Images (Case study Mandalay City). In 2023 IEEE Conference on Computer Applications (ICCA), 147-152. doi: 10.1109/ICCA51723.2023.10181968.

Evaluation of Morphometric Characteristics The Bhima River Basin, Maharashtra using Geospatial Techniques

Pandurang R. Bidkar
Associate Professor and Head (Retd.), Department of Geography, Daund Taluka Arts and Commerce College, Daund, Pune, Maharashtra, India
E-mail: bidkargeo62@gmail.com
Maya G. Unde
Professor and Head Department of Geography, B.P.H.E. Society's Ahmednagar College, Ahmednagar, Maharashtra, India.
E-mail: maya4unde@gmail.com
Namdev V. Telore
Professor, Department of Geography, Raja Shripatrao Bhagwantrao Mahavidyalaya, Aundh, Satara 415510, Maharashtra, India
E-mail: nvtelore@gmail.com

Article DOI Link: https://zenodo.org/records/10559055
DOI: 10.5281/zenodo.10559055

Abstract:

The study focuses on morphometry, which involves the measurement and analysis of the form of landforms. This research specifically examines the drainage characteristics of the part of Bhima River basin in Maharashtra. Utilizing Geographic Information System (GIS) techniques, morphometric variables are computed to analyze the basin's features. The ninth order stream is lies in the drought prone region of the Deccan Traps. A quantitative analysis of the drainage network reveals complex morphometric attributes, with lower-order streams predominantly influencing the basin. Strahler's (1964) stream order method is employed for stream ordering. The drainage density of the basin is determined to be 0.075 per km. It is observed that the lithology of the basin significantly affects erosional processes.

Keywords: Morphometric Analysis, Drainage Characteristics, Bhima River, GIS.

Introduction:

Morphometric characteristics are a mathematical and quantitative study of the Earth's surface arrangement, as well as the shape and magnitude of its landforms (Agarwal, 1998; Obi et al., 2002; Singh 2021). The measuring and quantitative analysis of the dimensions, forms and configurations of the earth's landforms is known as morphometry (Clarke, 1966). The stream ordering, stream length, stream length ratio, and bifurcation ratio are all included in the morphometry analysis. The drainage density, stream frequency, form factor, circulatory ratio, and elongated ratio are calculated in the aerial aspect.

Morphometric analysis holds a pivotal role in hydrological and hydrogeological studies, as emphasized by Agarwal et al. (2000), Unde and Telore (2012) and others. Its application serves to quantify and enhance the understanding of hydrological characteristics, providing crucial insights for the formulation of a comprehensive water resource management plan. This significance has been highlighted by Jawaharraj et al. (1998), Kumaraswami et al. (1998), Sreedevi et al. (2009) and Telore (2020). In contemporary practices, the utilization of GIS techniques has become prevalent for the assessment of diverse terrain and morphometric parameters within drainage basins. The adoption of GIS is attributed to its versatile environment and robust capabilities, making it a potent tool for the manipulation and analysis of spatial information. The examination of morphometric features within the drainage basin and channel network is essential for comprehending the hydro-geological characteristics, reflecting the influence of factors such as climate, geology, geomorphology, and structure. The correlation between various drainage parameters and the mentioned factors has been well acknowledged by Horton (1945), Strahler (1957), Melton (1958) and Gangalakunta et al. (2004), Shekar and Mathew (2022). In recent times, researchers have increasingly utilized remote sensing data and GIS to generate more precise morphometric parameters (Agarwal, 1998; Nag, 1998; Das and Mukherjee, 2005; Telore, 2020), affirming that remote sensing serves as a potent and valuable tool for analysing drainage morphometry.

The measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimensions of its landform provides the basis of the investigation of maps for a geomorphological survey (Bates and Jackson, 1980). This approach has recently been termed as Morphometry. The area, altitude, volume, slope, profile and texture of landforms comprise principal parameters of investigation. Dury (1952), Christian, Jenning and Tuidale (1957) applied various methods for landform analysis, which could be classified in different ways and their results presented in the form of graphs, maps or statistical indices.

Objectives:

1. To assess the linear morphometric characteristics of the study area.
2. To assess the areal morphometric characteristics of the study area.

Study Area:

The study area encompasses the stretch from Ujjani Dam to the confluence of River Man, spanning between 17° 2' 50" N to 18° 4' 26" N latitude and 75° 7' 12"E to 75° 37' 25" E longitude. Originating in the Western Ghats at Bhimashankar with an elevation of approximately 945 m ASL, the Bhīma River flows south-eastward through Maharashtra and Karnataka. It spans a total length of 861 km, ultimately merging with River Krishna about 26 km North at Raichur, situated at an altitude of 343 m ASL. After covering approximately 137 km from its source, the Bhima River receives the waters of the River Mula and Mutha from Pune on its right, and about 29 km downstream, it is joined on its

right bank by the Ghod River, which is fed by the Nira River. The Nira River originates in the Western Ghats and flows for a distance of 74 km before joining the Bhima River. The Bhima River forms the boundary between Maharashtra and Karnataka. The total catchment area of the River Bhīma is 76,614 km². Throughout its course, the Bhima River is augmented by numerous small rivers such as River Kundali, Bhima, Indrayani, and Pawana. Notable tributaries around Pune include River Indrayani, Mula, Mutha, and Pawana, all flowing through Pune and Pimpari Chinchwad city limits. In the Solapur district, major tributaries include River Chandani, Thamini, Moshi, Bori, Sina, Man, Bhogwati, and Nira. The confluence of River Nira and River Bhima occurs at Niranarsingpur in Malshiras Taluka, while River Man joins at Sarkoli in Manglweda Taluka in Solapur district.

The study area is specifically chosen from Ujjani Dam to the Niranarshingpur, where the Nira River confluences in the Solapur district, covering a total length of 36.66 km. Niranarshingpur serving as a pilgrimage site on the western bank of the River Bhima.

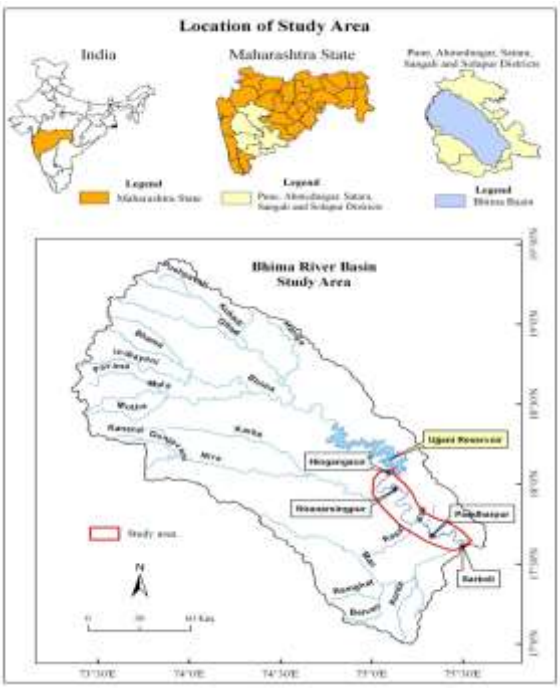


Figure 1: Location map of the study area

Materials and Methods:

The Morphometric analysis of the Bhima River basin was based on topographical maps on a 1: 50,000 scale, and different Morphometric parameters have

been generated in GIS environment. Digitization and the stream order were assigned by layer concept. The quantitative analyses of the basin which include stream orders, stream numbers, stream lengths, bifurcation ratios, basin circularity, drainage density, drainage frequency, drainage texture etc., have been analyzed through use of a GIS using Arc Info, which determines the geomorphic stage of development of the area. The drainage network of the basin is analyzed as per laws of Horton (1945) and stream ordering is made after Strahler (1964).

Morphometric Analysis:

a) Linear Aspects of the Drainage Basin:

1] Stream Order:

The Bhima River basin streams were classified based on the methodology outlined by Strahler (1964). Following Strahler's system, the convergence of two first-order streams results in a second-order stream segment, the merging of two second-order streams creates a third-order segment, and this pattern continues. The study area is identified as a ninth-order drainage basin, indicating the hierarchical level in the stream order classification.

2] Stream Number:

After assigning stream orders, the segments of each order are counted to get the number of segments of the given order (u). The stream lengths of the various segments are measured with the help of GIS software. In the study area, the total stream are present 1, 03, 557 of which 75.44 % are first order streams having 78,123 segments (Table 1). The second order stream segments are 19,442 and account for 18.77 %; Third order stream segments are 4,584 and accounted 4.42 %; Fourth order stream segments are 1,085 and account for 1.04%; Fifth order stream segments are 258 and account for 0.24 %; Sixth order stream segments are 50 and account for 0.048 %; Seventh order stream segment is 10 and account for 0.01 %; eight order stream segments are 4 and account for 0.0038 % and Ninth order stream segment is 1 and account for 0.0009 %.

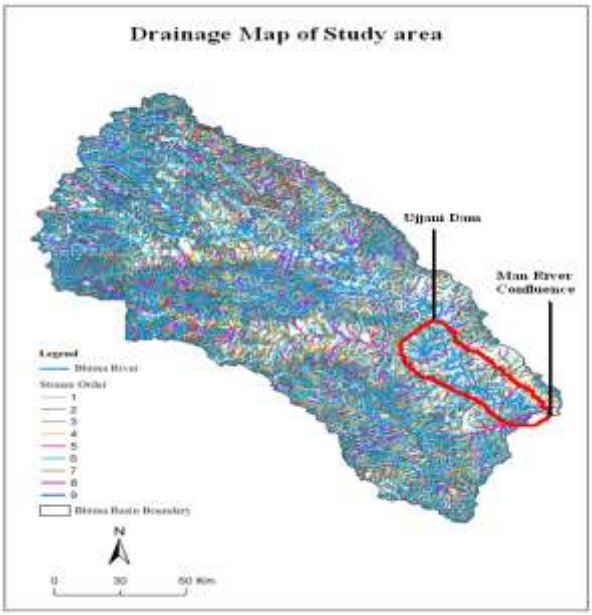


Figure 2: Drainage network of the study area

3] Bifurcation Ratio (Rb):

The Bifurcation Ratio, as defined by Horton (1945) and Strahler (1964), represents the ratio of the number of streams of a particular order to the number of streams of the next higher order. In the Bhima basin, the bifurcation ratio ranges from 2.5 to 5.16, as outlined in Table 1. The average bifurcation ratio for the area is calculated to be 4.16. This indicates that, on average, there are 4.16 times as many channel segments of any given order as there are for the next higher order.

Bifurcation ratios are closely linked to the structural control exerted on the drainage pattern (Nautiyal, 1994; Strahler, 1964; Chow, 1964). A lower range of bifurcation ratio suggests that structural factors do not significantly influence the drainage pattern, while a higher ratio indicates some level of geological control (Agarwal, 1998). The magnitude of Rb can influence the discharge characteristics of the basin, with a lower Rb leading to a sharp peak in discharge, and a higher Rb resulting in a lower but more prolonged peak flow (Agarwal, 1998). Typically, in well-developed drainage networks, the bifurcation ratio falls within the range of 2 to 5 (Horton, 1945; Strahler, 1964).

$$Rb = \frac{Nu}{Nu + 1}$$

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Table 1: Morphometric parameters of Bhima River basin

Stream Order	No of streams	No of streams %	Total Length in km	Mean Stream Length km	Bifurcation Ratio	Log of No of Streams	Log of total Length
1	78123	75.44	44538.23	0.57	-	4.89	4.65
2	19442	18.77	14460.31	0.74	4.01	4.28	4.16
3	4584	4.42	7542.96	1.65	4.24	3.66	3.87
4	1085	1.04	3990.00	3.68	4.22	3.03	3.60
5	258	0.24	1774.93	6.88	4.20	2.41	3.24
6	50	0.048	952.52	19.05	5.16	1.69	2.97
7	10	0.01	451.33	45.13	5.00	1.00	2.65
8	4	0.0038	231.17	57.79	2.50	0.60	2.36
9	1	0.0009	292.09	292.09	4.00	0.00	2.46
Total	1,03,557						

Here,

$$\text{MSL} = \frac{\text{Total Length of streams}}{\text{Number of streams in this order}}$$

4] Stream Length (Lu):

The measurement of stream lengths for different orders has been conducted using topographical maps. Horton's law (Horton, 1932), as endorsed by the theory articulated by Strahler (1964), posits that geometrical similarity is typically maintained in basins of increasing order. According to this law, the mean length of a channel (Lu) for a particular order (U) is determined by the ratio of the total length to the number of streams of that order. Notably, the mean length of channel segments for a given order surpasses that of the next lower order but falls short of that of the next higher order. A graphical representation involves plotting the logarithm of stream length for each order against the order itself. This process yields a series of points that generally align along a straight line. This visualization helps illustrate the adherence to Horton's law and the geometric regularity observed within the basin as stream orders increase, as explained by Strahler's insights from 1964.

b) Aerial Aspects of the Drainage Basin:

Basin Watershed area in study area:

Sr. No	Name of Watershed	Area of Watershed (km^2)	Length of Basin (km)
1	Ghod	4,546.17	407.12
2	Mula-Mutha	3,897.16	363.15
3	Nira	6,531.10	496.71

4	Man	4,756.85	421.27
5	Bhima	9,696.83	836.54
	Total	**29,428.11**	**2524.79**

1) Basin Area (Au):

The watershed area measures 29,493.97 km². As stated by Gregery and Walking (1973), 'L' represents the longest length of the basin from the catchment to the confluence point. The River Bhima basin has a length of 142.18 km. The basin area, a direct outcome of drainage development, often exhibits a pear-shaped morphology in early stages. However, as the cycle advances, the shape tends to become more elongated (Padmaja Rao, 1978). The shape of the basin is of significance as it influences stream discharge characteristics (Strahler, 1969). Conventionally, it is acknowledged that a circular area is more likely to exhibit a shorter lag time and higher peak flow compared to an elongated basin.Three dimensionless ratios, namely form factor, circularity ratio, and elongation ratio, serve as indicators of basin shape. These ratios offer valuable insights into the geometric characteristics of the basin, shedding light on its potential hydrological behaviour.

2) Form Factor (Rf):

The form factor, denoted as the ratio of basin area (Au) to the square of the basin length (Lb) as proposed by Horton (1932), is calculated for the Bhima basin. Specifically, the form factor for the Bhima basin is determined to be 0.0046.

$$Rf = \frac{Au}{Lb^2} \qquad Rf = \frac{29428.11}{(2524.79)^2} \qquad Rf = \frac{29428.11}{6374564.54} \qquad Rf = 0.0046$$

The form factor, with a value closer to zero, signifies a highly elongated shape, while a value closer to 1 indicates a more circular shape. Basins exhibiting a high form factor tend to have a peak flow of shorter duration, whereas an elongated basin with a low form factor results in a flatter peak flow lasting for a longer duration. Managing flood flows in elongated basins is generally considered more manageable than in circular basins (Nautiyal, 1994). The Bhima basin, characterized by its elongated shape, has a form factor (Rf) of 0.0046.

3) Circularity Ratio (Rc):

The Circularity Ratio is articulated as the ratio of the basin area (Au) to the area of a circle (Ac) with an equivalent perimeter (Pr) to that of the basin, following the definition by Miller (1953). This ratio is primarily influenced by the length, frequency, and gradient of streams of various orders, rather than the slope conditions and drainage pattern of the basins. In the case of the Bhima basin, this ratio is measured at 3.51.

4) Elongation Ratio (Re)

The elongation ratio is defined as the ratio of the diameter of a circle with the same area as the basin to the maximum length of the basin, following Schumm's (1956) formulation. In the study area, the calculated elongation ratio is 0.032. Typically, values ranging from 0.6 to 0.8 are generally associated with strong relief and steep ground slopes. However, in the present study area, there is no significant evidence of strong relief.

5) Drainage Density (Dd):

The Drainage Density (Dd) is a measure defined as the length of streams per unit area, obtained by dividing the cumulative stream length by the basin area as outlined by Horton (1932). In the Bhīma basin, the overall drainage density is recorded at 0.075 per km. Typically, a high Dd is indicative of regions characterized by non-resistant or impermeable subsurface materials, sparse vegetation, and mountainous relief. Conversely, a low Dd points to regions with highly resistant rock or highly permeable subsoil materials under dense vegetative cover, often associated with low relief. Within the study area, the hilly region to the west exhibits a notably high Dd, while it is significantly lower in the area closer to the coastal plain.

6) Stream Frequency (Fs):

Stream frequency in the basin is defined as the ratio of the total number of segments cumulated for all orders within the basin to the basin area, according to Horton (1945). For the entire basin, the stream frequency (Fs) is recorded at 3.51 streams/km². Elevated drainage density and stream frequency are indicative of a greater runoff from the basin.

7) Drainage Texture (T):

Drainage texture is defined as the relative spacing of drainage lines within a geographical area. The terms drainage density and drainage frequency together constitute the concept of drainage texture. It can be expressed by the equation (Smith, 1950) **T** = **D**d X **F**s. Classifications based on the values of T, as per Smith (1950), are as follows: 0-4 (Coarse), 4-10 (Intermediate), 10-15 (Fine) and Above 15 (Ultra Fine - associated with bad land topography). In the Bhima basin, the drainage texture is determined to be 0.263, indicating a coarse texture likely attributed to the presence of massive and resistant rocks.

Conclusion:

The Bhima River basin of Maharashtra State was chosen for the analysis in this current study. The study indicates that the drainage area of the basin is transitioning from an early mature stage to the old age stage within the fluvial geomorphic cycle. The dominance of lower-order streams is notable in the basin, and the development of stream segments is influenced, to some extent, by rainfall patterns. Observation reveals that stream segments up to the third order traverse high altitudinal zones characterized by steep slopes, while the fourth, fifth, and sixth order segments occur in relatively flat

lands. The average bifurcation ratio of 4.16 suggests a well-developed drainage network in the study area. The results of this analysis would be useful in determining the effect of catchment characteristics such as size, shape, slope of the catchment and distribution of stream network within the catchment.

References:

1. **Agarwal CS (1998**) Study of drainage pattern through aerial data in Naugarh area of Varanasi district, U.P. J Indian Soc Remote Sensing 26:169–175. https://doi.org/10.1007/BF02990795
2. **Chow Ven, T. (1964):** (ed) handbook of Applied hydrology. McGraw Hill Inc, New York.
3. **Clarke JJ (1966)** Morphometry from maps. Essays in geomorphology. Elsevier, New York, pp 235–274
4. **Das, A.K. and Mukhrjee S. (2005):** Drainage morphometry using satellite data and GIS in Raigad district, Maharashtra. Geol. Soc. India 65:577 – 586.
5. **Dury, G. H. (1952):** "Methods of Cartographical Analysis in Geomorphological Research", Silver Jubilee Volume, Indian Geographical Society, Madras, pp 136-139.
6. **Gregory, K. J. and Walling, D. E. (1973):** drainage basin form and process a geomorphological approach. Arnold, London.
7. **Horton, R. E. (1945):** Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology.Geol Surv Profess, 282 A.
8. **Jawaharraj, N., Kumaraswami, K., and Ponnaiyan, K (1998):** Morphometric analysis of the Upper Noyil basin (Tamil Nadu). Journal of the Deccan Geographical Society, 36, pp 15-29.
9. **Kumaraswamy, K and Sivagnanam, N (1998):** Morphometric charecteristics of the vaippar Basin,Tamil Nadu: A qualitative approach, Indian Journal of Landscape System and Ecological Studies, 11 (11), pp 94-101.
10. **Melton, M. A. (1958):** Correlation strucrture of morphometric properties of drainage system and their agents. Jour. Geol. 66: 442-460.
11. **Miller, V. C. (1953):** a quantitative geomorphic study of drainage basin charecteristics in Clinch Mountain Area, Virginia and Tennessee. Technical report, 3, Office of the Naval Research. Dept. of Geology, Columbia Univ., New York.
12. **Nag, S. K. (1998):** Morphometric Analysis using remote sensing techniques in the Chaka Sub-basin, Purulia district, West Bengal. J. Indian Soc. Remote Sensing 26(1 and 2): 69-76.
13. **Nautiyal, M. D. (1994):** Morphometric Analysis of a Drainage Basin using Aerial photographs: A case study of Khairakulli Basin, District Dehradun, Uttar Pradesh. Journal of the Indian Society of Remote Sensing, 22 (4), pp 251-262.

14. **Obi RGE, Maji AK, Gajbhiye KS (2002)** GIS for morphometric analysis of drainage basins. GIS India 4(11):9–14
15. **Padmaja Rao, G. (1978):** some Morphometric Techniques with Relation to Discharge of Musi basin, Andhra Pradesh, pp168176, proc. Sump on Morphology and Evolution of Landforms, Department of geology, university of Delhi, New Delhi 110 007, pp 22-23.
16. **Schumm, S. A (1956):** evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersy. National Geological Society of American Bulletin, 67, pp 597-646.
17. **Shekar, P.R., Mathew, A.** Morphometric analysis for prioritizing sub-watersheds of Murredu River basin, Telangana State, India, using a geographical information system. *J. Eng. Appl. Sci.* 69, 44 (2022). https://doi.org/10.1186/s44147-022-00094-4
18. **Smith, K. G. (1950):** standards for grading texture of erosional topography. Am J Sci 248, pp 655- 668.
19. **Strahler, A. N (1964):** quantitative Geomorphology of drainage basins and channel networks. Handbook of Applied Hydrology; edited by V.T Chow (Newyork; Mc Graw hill) Section, pp 411.
20. **Strahler, A. N. (1969):** Quantitative geomorphology of drainage basin and network Handbook of Applied Hydrology (Ed By Ven Te Chow) Mc Grew Hili Book Company New York.
21. Singh WR, Barman S, Trikey G (2021) Morphometric analysis and watershed prioritization in relation to soil erosion in Dudhnai Watershed. Appl Water Sci. https://doi.org/10.1007/s13201-021-01483-5
22. **Sreedevi PD, Owais S, Khan HH, Ahmed S (2009)** Morphometric analysis of a watershed of south India using SRTM data and GIS. J Geol Soc India 72:543–552
23. **Strahler AN (1950)** Equilibrium theory of Erosional slopes, approached by frequency distribution analysis. Am J Sci 248:673–696
24. **Strahler AN (1952)** Dynamic basis of Geomorphology. GSA Bull 63(9): 923–938 https://doi.org/10.1130/0016-7606(1952)63[923:DBOG]2.0.CO;2
25. **Strahler AN (1956)** Quantitative slope analysis. Bull Geol Soc Am 67:571–596
26. **Strahler AN (1964**) Quantitative geomorphology of drainage basins and channel networks. In: Chow VT (ed) Handbook of applied hydrology. McGraw Hill, New York, Section 4–11. http://geomorphometry.org/content/quantitative-geomorphology-drainage-basinsand- channel-networks
27. **Unde, M.G. and Telore, N.V. (2012).** Role of Watershed Development Programme in Sustainable Development: Nidhal Experience from Satara District, Maharashtra. J Shivaji University (Sc & Tech) Vol 42, 2012, 68 - 71. ISBN 978-81-926964-0-9 www.unishivaji.ac.in/uploads/journal/Journal_42/16.pdf

28. **Telore N.V. (2020)** Quantitative Morphometric Analysis of the Yerla River Basin, Deccan Trap Region, India. In: Sahdev S., Singh R., Kumar M. (eds) Geoecology of Landscape Dynamics. Advances in Geographical & Environmental Sciences. Springer, Singapore, 115-132, March 2020, https://link.springer.com/chapter/10.1007/978-981-15-2097-6_9

Assessment of the GIS Based Characterization of Channel Morphology and Sinuosity Indices In Part of Floodplain in the Waingangā River, Maharashtra, India

Ravindra Bhagat
Assistant Professor, Department of Geography, S.S. Dhamdhere Arts and Commerce College, Talegaon Dhamdhere, Tal-Shirur, Pune, Maharashtra, India.
Email: ravindra.bhagat1@gmail.com

Article DOI Link: https://zenodo.org/records/10559066
DOI: 10.5281/zenodo.10559066

Abstract:

Changes in the channel bed, bank erosion have been considered as measure of geomorphic effectiveness of floods. For the Wainganga River, discharge, rainfall runoff, data regarding erosion of bed and banks or changes in the cross section or longitudinal profile. So, any river and stream morphology with a specific emphasis on how river channel morphology effect on urbanization and human impacts. In the study of rivers, specifically looking at how the channel geometry changes with time that affect the channel morphology like as, bank and bar stability, sediment size distribution, sediment supply, flow variability downstream slope, width and height etc. So, in order to evaluate the changes due to floods in the channel bed and banks, cross section in various stages and also understanding which factors affect channel form is vital in constructing realistic and accurate models of rivers and how they change over time.

Keywords – Wainganga River, longitudinal Profile, Sinuosity indices etc.

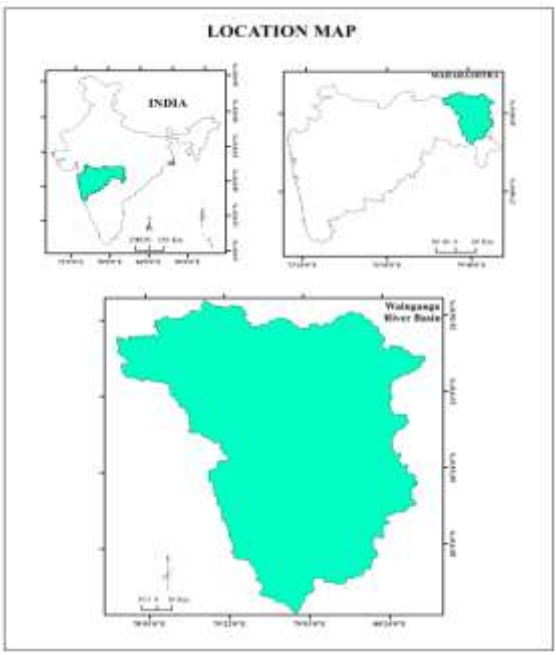
Introduction:

Morphological Studies of rivers are very important to study the behaviour of a river, its aggradations or degradation, shifting of the river course, erosion of river bank etc. and to plan remedial measure for erosion and other related problems. The channel of the Wainganga River in high monsoon flows are confined within the channel. The channel fill discharges infrequently occur. Consequently, the adjustment in width depth ration and hydraulic variables with increasing discharge take place. The examination of the longitudinal profile of a river in evolves stages and its indicates that emerges from the analysis is that the flows become deeper and efficient as the discharge increases. Therefore, large flood flows are geomorphologically and environmentally more effective than low or moderate flows. The present study is focused on the analysis of the Topography, Watershed, and longitudinal profile of the Wainganga River has been earlier eroded or deposited of sediment with the help of geospatial technology. To achieve this goal researcher has prepared different cross section area in a channel through Geographical Information System (GIS). The assessment of various morphological

parameters of the Wainganga Basin in India by applying geoprocessing methods such as the ARC map module in ARC GIS 9.3 and ERDAS imagine 9.2., all parameters were computed mathematically to analyses the characteristics of different morphological and hydrological parameters for sustainable development and planning of the river basin.

Study Area:

The Wainganga River rises at an elevation of 640.0 m near village Partabpur (21°57'N & 79°34'E) about 20 Km from the town of Satpura plateau and flows in a wide half-circle, bending and winding among the spurs of the hills from the west to the east of the Seoni District of Madhya Pradesh.. The WRB total area of 49949.48 sq. km., while the Latitude extension- 19°30'N to 22°30 N' & Longitude extension- 79°00'E to 80°30 E'. The total length of the Wainganga River is 638.91 km, of which 270.2 km lies in Madhya Pradesh. The river travels 32 km along the border between Madhya Pradesh and Maharashtra, while the remaining 336.17 km lies in Maharashtra.



Map No. 1 Study Area of Wainganga Basin

Objective -

1. To examine or to study about channel morphology of study area.
2. To understand of the Wainganga River sinuosity index in various stages.
3. To study about the Channel morphology changes in to flood situation.

Hypothesis- Morphological Studies of rivers are very important to study the behaviour of a river and its changes to longitudinal profile.

Statement of the Problems –

Wainganga River characterized by numerous cutoff channels and hills that's why sandbars are developed in the convex side of meanders. Understanding these processes is crucial for managing river systems, especially in regions where rivers play a significant role in shaping the landscape and influencing the surrounding environment.

Identification of Research Gap -

A comprehensive study using GIS technology to analyze and characterize the channel morphology and sinuosity indices in a specific part of the floodplain associated with the Waingangā River in Maharashtra. Such assessments are valuable for understanding the dynamic nature of river systems, which is crucial for informed decision-making in areas related to water resource management, environmental conservation, and land use planning.

Methodology:

The topographical data is obtained from a one-inch topographic map of Survey of India (1:63360 or 1:250000) with the help of toposheets No. 55J, 55K, 55N, 55O, 55P,56M, 64B, 64C, 64D, 65A. Using these sheets we have carried out various classification and analysis which includes sorting of data, digitization of various layers, preparation of maps, statistical analysis, and other GIS/RS techniques. In this study, the Wainganga River Basin was delineated and the drainage network was extracted using Cartosat-DEM (1 arcsec) superimposed with SOI toposheets, GPS location, river hydrology including rainfall distribution, run-off are calculated by statistical methods, like as, Mann Kendall Trend Test (sometimes called the M-K test and Modify Mann Kendall Trend Test called the MMK test). After completion of DEM, the flow direction was calculated for each pixel, to generate a drainage network, the flow accumulation was taken into account, based on the flow direction of each cell. Thus GIS-based analysis of topography, watershed, and hydrological parameters has been calculated for the sustainable development of the Wainganga River Basin.

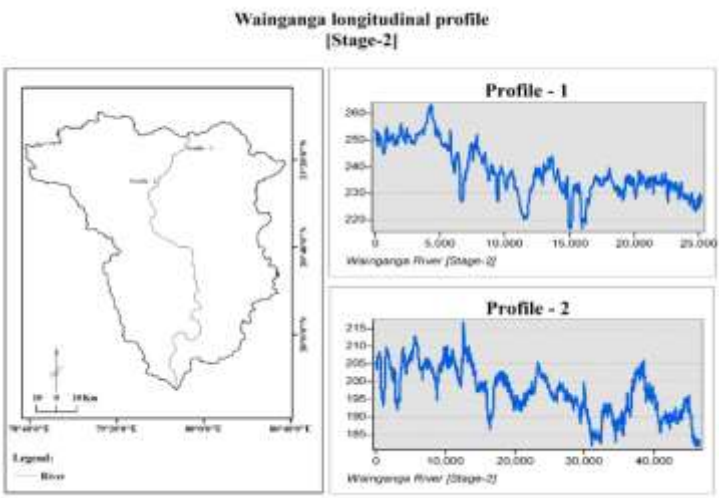
Results and discussions:

Longitudinal Profile of the Wainganga River Basin

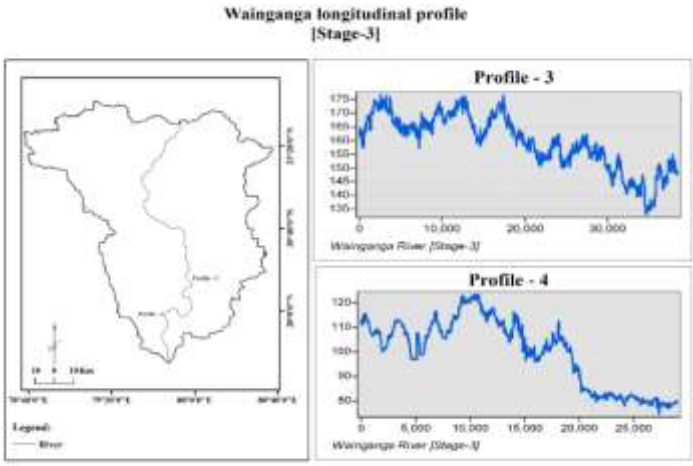
The channel gradient or longitudinal profile represents fall in bed elevation with distance down channel. The overall cannel gradient declines in the downstream direction, and tends to attain a concave-to-the-sky form. (Sharma V. K. 1986)

The longitudinal profile of a river is a property of river geometry that can provide clues to underlying materials as well as insights into geologic processes and geomorphic history of an area (Hack, 1960). The longitudinal profile of a river channel may be shown graphically by a plot of altitude (ordinate) as function of horizontal distance. The long profile shows how a river's gradient changes as it flow from its source to its mouth. The long profile shows how, in the upper stage of a rivers course, the rivers gradient is steep but it gradually flattens out as the river erodes towards its base level.

The construction of longitudinal profile provides an interpretation of the surface history and the river course flows from the source to mouth at any stage of evolution. (Kumar and Pandey, 1981). Filed observation along some location on the Wainganga River indicates that the high alluvial channel bank is steep in first stage but stable and there is almost complete absence of vegetation cover. The longitudinal profile is drawn for the three courses of the river as is covered by survey of India toposheet number 55K, 55O, 55P, 56M, 64C, 64D, 65A. (Map No.4). In the profile shown in the flow calculation result, there are trends of rising in the longitudinal profile that is inconsistent with the real tendency of a river channel. These errors are associated with the scale of representation of the DEM. This is because the geometric complexity of the Wainganga River is not reflected in the low-resolution digital maps, so that the flow calculation algorithm has to do local ascents to find the general trend of maximum slope from the starting point. In the case of 640-meter DEM resolution this error is very remarkable, as can be seen in the calculated profile. This new representation shows how local promotions have been virtually eliminated, showing a continuous trend of decrease in altitude consistent with the actual longitudinal profile of a river.

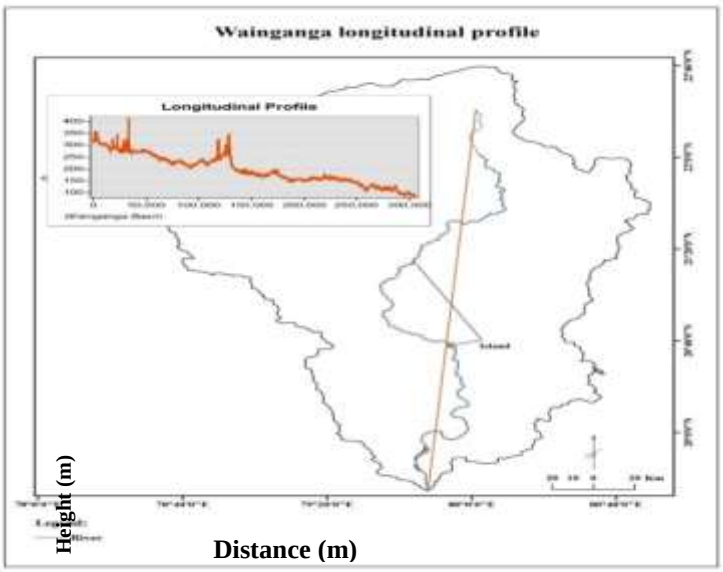


Map No. 2 Longitudinal Profile of Wainganga River (Stage II)



Map No. 3 Longitudinal Profile of Wainganga River (Stage III)

The longitudinal profile shows some changes from source to mouth in profile 1 and 2. But some deposition is observed near left and right bank. In majorly The Wainganga sub-basin is naturally prone to flooding, with floods being recorded every 5-7 years. Recently the Wainganga basin has experienced floods in 1994, 1998, 2001, 2004, 2007 and 2014. In many cases the floods have been a result of continuous heavy rainfall in upstream areas or throughout the basin. Analysis based on the channel cross profile foe two sites in the alluvial reaches indicate lack of substantial impact during flood in alluvial section. It is proposed that the channel is adjusted to and maintained by only large infrequent floods, not altered for long period of time. (Gupta *et.al*, 1999), with high alluvial banks, inclosing a large channel point bar, a smaller low flow channel and patches of flood plain.



Map No. 4. Longitudinal Profile of Wainganga River

Above examination of the longitudinal profile of a river reveals that such a river evolves through three main stages:

1. An early stage where the gradient is steep, and where erosion by the river prevails over its depositional powers (Map No.3).
2. An intermediate stage, where the river begins to erode laterally, widening its channel and at the same time depositing material, thus maintaining some kind of equilibrium between erosion and deposition (Map No.2).
3. A late stage close to the river's mouth, where the gradient becomes shallow, and the river loses its energy, thus depositing most or its entire load (Map No.2).

These three stages are known as Youth, Maturity and Old age, respectively (Map No.2 and 3).

Sinuosity Indices

For single-thread stream channels, the sinuosity index is calculated for each reach using its two endpoints (Upstream point A, Downstream point B). The ratio of the sinuous length the straight-line distance is Channel Sinuosity value for the reach. The sinuous length is measured down the centerline of the channel. Divide the sinuous length by the straight-line distance between the same two points.

J. E. Muller's Model (1968)

Muller presented his own model of sinuosity index in terms of hydraulic and topographic sinuosity, which requires the measurement of channel length (CL), valley length (VL) and the shortest distance between the source and the mouth of river (Air L), and calculation of a few indices.

Where,

CI = Channel Index

CL = Channel Length

AL = Air Length, (Shortest distance between the source and the mouth of a river).

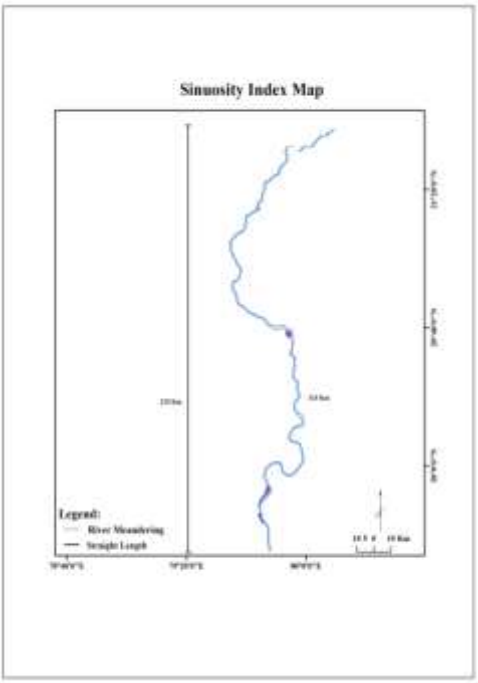
Wainganga River Sinuosity Index = 324 / 229 = 1.41

The above calculation the sinuosity indexes have been calculated for the present study region. (Map No.5). With the above preparation, the SSI of river courses may be grouped into three kinds, Straight river course when the SSI is 1.00. It is clearly to be noted that the river may not have straight course as close parallelism between the shortest straight length of a river and a length actually adopted by river is a remote possibility.

Sinuous course when the SSI ranges between 1.00 and 1.5.

Meandering course when SSI is more than 1.5.

Wainganga river sinuosity index is1.41 it means near meandering course.



Map No. 5 Sinuosity Indices

Conclusion:

As a result of intense monsoonal activities Wainganga basin subjected to floods every year. Wainganga river characterized by numerous cutoff channels and hills. Sandbars are developed within the channel as well as in the convex side of meanders.

Natural levees are formed at the edge of point bars bordering the channel. The resulted changes in this way include downstream migration of meander, widening of river course and removal and deposition of sandbars. The processes involved in changes of river morphology in Wainganga are avulsion, bank retreat and neck cut-off. The Wainganga River and its tributaries carry huge amount of sediments at the monsoon season. They are deposited whenever the water is out on the banks. The coarse sediments thus deposited reduce soil fertility.

References:

1. **Barrow C (1998)** River basin development planning and management: a critical review. World Dev 26(1):171–186. https://doi.org/10.1016/S0305-750X(97)10017-1
2. **Bisen DK, Kudnar NS (2013a)** A sustainable use and management of water resource of the Wainganga River basin: a traditional management system. J Contrib. https://doi.org/10.6084/m9.figshare.663573.v1
3. **Bisen DK, Kudnar NS (2013b)** Watershed development: a case study of drought prone village darewadi source, review of research [2249-894x] d -1-6.
4. **Bisen DK, Kudnar NS (2019)** Climatology, Sai jyoti Publication Nagpur, pp-23-112.
5. **Bhagat, R. S. (2020)** "Longitudinal Dispersion Characteristics of Wainganga River and Natural Streams, India," Our Heritage, ISSN: 0474-9030 Vol-68-Issue-1- Pp. 884 to 892.
6. **Bhagat R.S., Kudnar N.S. and Shinde H.D. (2021**) "GIS-Based Multi-criteria Approach towards Sustainability of Rainfall distribution and Flood hazard Areas in Wainganga River in Maharashtra, India," Maharashtra Bhugolshastra Sanshodhan Patrika, Vol. 38, No.2, pp 39-46
7. **Choukr-Allah R., Nghira A., Hirich A., Bouchaou L (2016)** Water Resources Master Plan for Sustainable Development of the Souss-Massa River Basin. In: Choukr-Allah R., Ragab R., Bouchaou L., Barceló D. (eds) The Souss-Massa River Basin, Morocco. The Handbook of Environmental Chemistry, vol 53. Springer, Cham, 1-26. https://doi.org/10.1007/698_2016_67
8. **Elmahdy SI, Marghany MM, Mohamed MM (2016)** Application of a weighted spatial probability model in GIS to analyse landslides in Penang Island, Malaysia. Geomat Nat Hazards Risk, 7, 345–359. doi:10.1080/19475705.2014.904825
9. **Gosain AK, and Rao S (2004):** GIS-Based Technologies for Watershed Management. Current Science, vol. 87, no. 7, pp. 948–953. JSTOR, www.jstor.org/stable/24109399
10. **Kadam AK, Umrikar BN, Sankhua RN (2020)** Assessment of recharge potential zones for groundwater development and management using geospatial and MCDA

technologies in semiarid region of Western India. SN Appl. Sci. 2, 312. https://doi.org/10.1007/s42452-020-2079-7

11. **Khadr M (2017)** Temporal and spatial analysis of meteorological drought characteristics in the upper Blue Nile river region. Hydrol Res 48(1):265–276. https://doi.org/10.2166/nh.2016.194
12. **Kudnar NS (2015a)** Linear aspects of the Wainganga River basin morphometry using geographical information system. Mon Multidiscip Online Res J Rev Res 5(2):1–9
13. **Kudnar NS (2015b)** Morphometric analysis and planning for water resource development of the Wainganga river basin using traditional & GIS techniques. University Grants Commission (Delhi), pp 11–110
14. **Kudnar NS (2017)** Morphometric analysis of the Wainganga river basin using traditional & GIS techniques. Ph.D. thesis, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, pp 40–90
15. **Kudnar NS (2020)** GIS-based assessment of morphological and hydrological parameters of Wainganga River basin, Central India. Model. Earth Syst. Environ. 6, 1933–1950. https://doi.org/10.1007/s40808-020-00804-y
16. **Kudnar NS, Rajasekhar M (2020)** A study of the morphometric analysis and cycle of erosion in Waingangā Basin, India. Model. Earth Syst. Environ. 6, 311–327. https://doi.org/10.1007/s40808-019-00680-1
17. **Islam MS, Han S, Masunaga S (2014)** Assessment of trace metal contamination in water and sediment of some rivers in Bangladesh. Journal of Water and Environment Technology, 12(2), 109–121. https://doi.org/10.2965/jwet.2014.109.
18. **Mazzorana B, Nardini A, Comiti F, Vignoli G, Cook E et al (2017)** Toward participatory decision-making in river corridor management: Two case studies from the European Alps. Journal of Environmental Planning and Management. https://doi.org/10.1080/09640568.2017.
19. **Nassim Al-Abed & Munjed Al-Sharif (2008)** Hydrological modeling of zarqa river basin – jordan using the hydrological simulation program – fortran (HSPF) ModelWater Resources Management Volume 22, Issue 9, pp 1203–1220 https://doi.org/10.1007/s11269-007-9221-9
20. **Paranjpye V (2013)** A Master Plan for Integrated Development and Management of Water Resources of Wainganga Sub- Basin. pp. 10- 37.
21. http://cwp-india.org/wp-content/uploads/2018/03/Report-on-Integrated-Development-and-Management-Plan-Wainganga-river-sub-basin.pdf
22. **Rajasekhar M, Gadhiraju SR, Kadam A et al (2020)** Identification of groundwater recharge-based potential rainwater harvesting sites for sustainable development of a semiarid region of southern India using geospatial, AHP, and SCS-CN approach. Arab J Geosci, pp 13-24. https://doi.org/10.1007/s12517-019-4996-6

23. **Singh P, Gupta A, Singh M (2014)** Hydrological inferences from watershed analysis for water resource management using remote sensing and GIS techniques. Egyp J Remote Sens Space Sci 17:111–121. https://doi.org/10.1016/j.ejrs.2014.09.003
24. **Texak A, Murumkar AR, Arya DS (2014):** Long term spatial and temporal rainfall trends and homogeneity analysis in Wainganga basin, Central India, Water and Climate Extremes, volume 4. pp. 50-61. https://doi.org/10.1016/j.wace.2014.04.005
25. **Yang M, Yan D, Yu Y, Yang Z (2016)** SPEI-based spatiotemporal analysis of drought in Haihe River Basin from 1961 to 2010. Adv Meteorol 2016(10):1–10. https://doi.org/10.1155/2016/7658015
26. **Yousif M, Bubenzer O** (2015) Geoinformatics application for assessing the potential of rainwater harvesting in arid regions. Case study: El Daba'a area, Northwestern Coast of Egypt. Arab J Geosci 8:9169–9191. https://doi.org/10.1007/s12517-015-1837-0
27. **Zhang Q, Xu C-Y, Zhang Z (2009)** Observed changes of drought/wetness episodes in the Pearl River basin, China, using the standardized precipitation index and aridity index. Theor Appl Climatol 98(1):89–99. https://doi.org/10.1007/s00704-008-0095-4

Dhara Vikas: A climate change initiative to revive drying springs in Sikkim Himalayas

Subash Dhakal
Deputy Director, Rural Development Department, Government of Sikkim, Gangtok, 737101, Sikkim, India
Email: pkysub2@gmail.com
Sher Bahadur Karki
State Dhara Vikas Coodinator, MGNREGA Division, Rural Development Department, Government of Sikkim, Gangtok 737101, Sikkim, India
Email: karkiabiral@gmail.com

Article DOI Link: https://zenodo.org/records/10559075
DOI: 10.5281/zenodo.10559075

Abstract*:*

Dhara Vikas initiative, an action research, was started by the Rural Development Department, Government of Sikkim, in 2008 following learning by doing approach. The earlier approach of individual springs (source-based approach) having their confined aquifers was improvised with a mountain aquifer approach targeting a cluster of springs around the hill or a range with the perception that aquifers are interlinked with a network of deep-seated fractures. This inference was drawn after a natural isotope study done to identify the recharge area by Dhakal et, al.,2014, which suggested that the water sample from the spring had isotope signatures of different places spread over the Pandam Hill range in East Sikkim. Moreover, analysis of the distribution of springs over various physical parameters has been attempted using GIS mapping. The result showed more than 80% of the springs are distributed between the elevation range of 600 to 1800 m ASL and slope class of 10 degrees to 40 degrees. More than 50 % of the spring points are spread over the agriculture fields inferring agriculture fields were developed around the water sources in the mid hills. Distribution over different forest types revealed that most of the springs emerged from the zone of subtropical wet hill forest between elevations of 1400 to 1800 ASL. The result from the pilot intervention following the mountain aquifer approach showed an increase in lean season discharge of more than 80% for Kharkhare Kholsha and 70% for Aitabarey and Nunthaley Dhara in the Deythang landscape project. The results from the Tendong landscape project showed an increase in lean season discharge from 21% to 107% for 5 springs abutting the Tendong range. Similarly, an increase in lean season discharge from 10% to 15% was reported from the Sadam landscape project according to the assessment done by IISC Bangalore.

Keywords: Rural Development, Sikkim, Action Research, Springs, Dhara Vikas

Introduction:

Even though the Himalayas are referred to as the water towers of Asia, their uneven distribution in time and space comes in the way of the development needs of the region (Vashisht and Sharma, 2007). Though mountains provide life-giving water to millions downstream, water is becoming scarce in the middle mountain regions of the Himalayas. (Merz, ET, al, 2003). In the Himalayan region, mountain springs are the main source of water for drinking and other household purposes. The amount of spring flow during rainy and nonrainy seasons is affected by rainfall and recharge area characteristics (Negi and Joshi, 1996, 2004). The water discharge behaviour of springs also shows the structural control over the discharge of these springs (Negi, et al., 2007). Numerous Studies have shown that the discharge from these sources has been decreasing drastically over the years. Climatic changes, such as an increase in rainfall intensity and a reduction in the winter rain, could be reasons for the decrease in discharge (Tambe et al 2012). Spring discharge corresponds to rainfall and winter rain is significant for maintaining lean season discharge (Rai et. al., 1998, Agarwal, et, al,2014). The hydrological role of the forest is weakening due to growing anthropogenic activities in the catchment areas (Spears 1982, Myers 1983, Bruijnzeel, 2004, Sharp and Sharp, 1982). The impacts of which can be manifested in the hydrological behaviour of streams and springs (Singh & Rawat, 1985; Valdiya & Bartarya, 1989; Valdiya et. al., 1991; Negi et. al., 1998; Negi, 2001, 2004; Negi & Joshi, 2004).

To address the problem of "Springs drying", the Rural Development Department, Government of Sikkim has experimented an action reserach to address the problem with the initiative called *Dhara Vikas* since 2008. Can the Himalayan Springs be revived? What approach needs to be followed? What would be the impact? etc., were pertinent research questions before the initiative. Review of literature did not provide any success stories to base the initiative. The initiative started following the watershed approach considering spring as a 1st order drainage. This approach did not revived the targeted springs. Upon much brainstorming, dialogue and deeper engaemenent with thematic experts and premier institutes, the significance of underground geology in Himalayan ground water movement and storativity was better understood. hydro-geological assessment became the crux to unbox the complex natural system of the springs in the Himalayas. Innitially, the focus was on the individual springs. This was called a "spring based approach based on hydrogeology". However, due to fragile geology in the Himalayas, the deeper interconnected fractures changed the dimension of the perceived acquifers below. This informed the implementers to change the focus from the springs (source) to the acquifers (resource). Presently, the approach followed to revive the springs is "acquifer based approach" wherein the cluster of springs abutting the hill or a range is considered. Therefore, the rural development depertment followed a " learning by doing approach" to revive the drying springs in the Himalayas. The

acquifer based approach is also validated by studies using natural isotopes which suggested that the recharge area usually does not occur at a single location but instead occurs over a larger area probably over the entire length of the aquifer (Manga, 2001, Dhakal et al 2014). Sikkim Himalayas at large may not have a confined aquifer system for individual springs. This was evident from the very low success of improving the spring discharge when intervention was done for individual springs . The extent of the recharge area in the former approach was 2- 3 hectares which increased to more than 20 hectares in the latter approach. The latter was targeted to recharge the aquifer which was assumed to be interconnected as a network of cracks and fractures developed over metamorphic areas of Sikkim. Some of the springs were manually monitored for several years before and after intervention which has shown promising results. In places where the discharge data was not collected, the success of the spring recharge programme came in the form of positive feedback from the villagers who have been using the spring water for ages.

Objective of the initiative

1. Action research to address the issue of drying springs.
2. To design the standard methodology to be followed to revive the drying springs.
3. Incorporate the devised methodology in various programmes to solve the problem of water scarcity in the mid- mountain regions of Sikkim Himalaya.

Designing the Initiative:

This initiative has its genesis in an environmental challenge faced by the local community. In 2008 in a workshop on world water day, the women farmers from the mid-hills highlighted the issue of drying up of perennial springs during the lean season resulting in untold hardships. Earlier responses focused on planting wild bananas (*Musa* sp.) and dhokreyphul (*Datura stramonium*) around the water source and erecting a loose-stone masonry wall around the water source. The questions for science were –what is the source of spring water, is the spring discharge linked to rainfall pattern and can these springs be revived? These questions were posed to several academic institutions namely

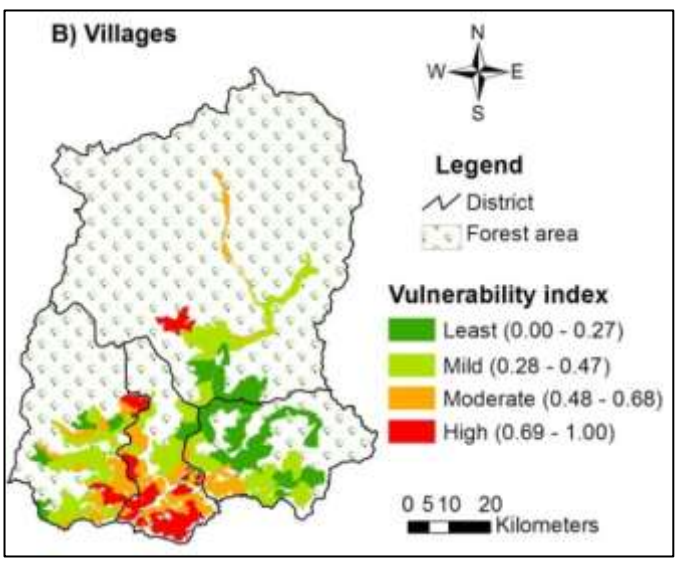
WWF-India, People's Science Institute (PSI), G. B. Pant Institute of Himalayan Environment and Development (GBPIHED) and Advanced Center for Water Resources Development and Management (ACWADAM). These academic institutions helped design pilots to develop a standard methodology for a spring revival. With funding support from MGNREGA, a spring revival initiative (*Dhara Vikas*) was launched. The follow-up of this initiative was to supplement the natural groundwater recharge, by first identifying the recharge area of the aquifers feeding the springs and then taking up artificial recharge works like digging trenches and ponds to catch the surface flow and enhance the infiltration.

Photo 1: hardship faced by women carring water uphill as the accessible sources have dried up in lean season

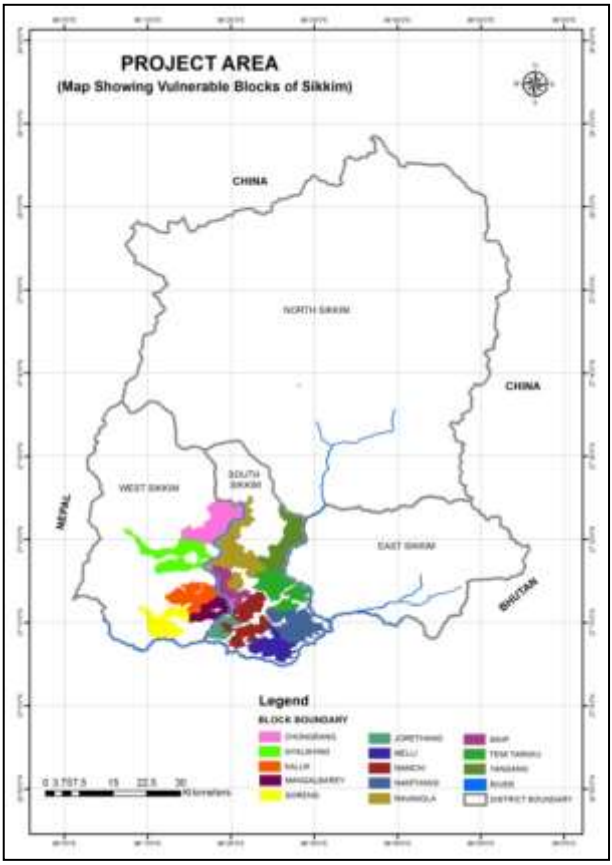
Project area

To geographically target climate change adaptation programs, the climate-change-related vulnerability assessment study at the Gram Panchayat level was carried out in-house (Tambe *et al.* 2010). Based on the above study the initiative was geographically targeted in the drought-prone rain-shadow areas of the South and West districts of Sikkim

Figure 2: Project area for spring shed development (Dhara Vikas)



ISBN: 978-93-94819-25-2,
Advances in Geographical Research



Methodology:

The proposed mountain aquifer approach envisages the understanding that springs/clusters of springs over a larger area extent may be an entire hill or a part of a mountain range. Thus, it becomes pertinent to understand the distribution of springs vis a vis elevation, slope, land use, aspect etc. Secondly, based on the approach few pilots were undertaken for a cluster of springs in the west and south districts of Sikkim. These works were undertaken by the department in different financial years as a regular programme under MGNREGA. The first project was undertaken at Phunsebong Reserve Forest at Deythang, West Sikkim, between 2010 to 2011. The second project was undertaken in Sadam and Mungram Reserve Forest in the year 2012-13 and the third at Tendong Hill Namchi in 2013-14. The process involved the proposed work being passed in the Gram Shaba, geo-tagging the targeted springs in the area, assessment of geological structures with their geo-location by trained para-hydro-geologist, identification of

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

recharge area, preparation of estimate and sanction from District project coordinator (DPC) and execution of work under the supervision of experts. The pre and post-intervention data was collected from selected springs in the first and third project sites.

For analysis and documentation, maps were prepared using Survey of India toposheets and geological maps from the Geological Survey of India on the Scale of 1:50,000. Different GIS layers were created and the data from the field was incorporated to get the desired output.

Springs mapping:

The location data and other attributes of the springs were collected manually from the field for about 2000springs from the west and south district using GPS. The data was imported into the GIS platform to different layers for analysis. The information derived from the GIS mapping of the springs is discussed below:

Distribution of springs over different elevation classes:

Spring points for the south and west district were overlaid on the elevation layer. The data shows 36% of the springs are located between elevation classes 1000 to 1400 (Fig 3 & 5). About 23% of each spring is located in the elevation classes 600-1000 and 1400-1800 respectively. Thus, from the data, it is evident that more than 80% of the spring points are located between the elevation level 600 to 1800M ASL. The district does not have any snow-clad peaks and most of the water bodies are seasonal and fed from the base flow. The incidences of spring drying during the lean season are also more pronounced in the south district.

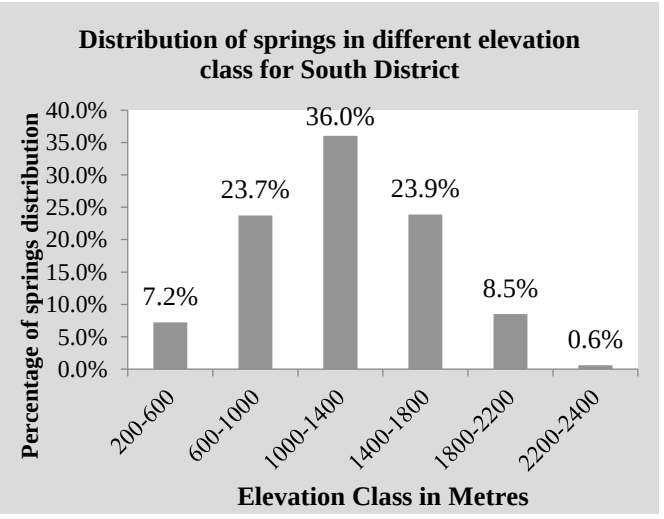


Fig 3: Distribution of springs in different elevation classes for South District

Similarly, the data analysis for the West district (Fig 4 & 6) shows that 32% of springs are located between elevation classes 1400 -1800 and 30% between elevation classes

1000-1400 m ASL. However, compared to the south district (8.5%) about 18 % of springs are found above 1800 m ASL in the west district. There are ranges with snow cover during the winter season.

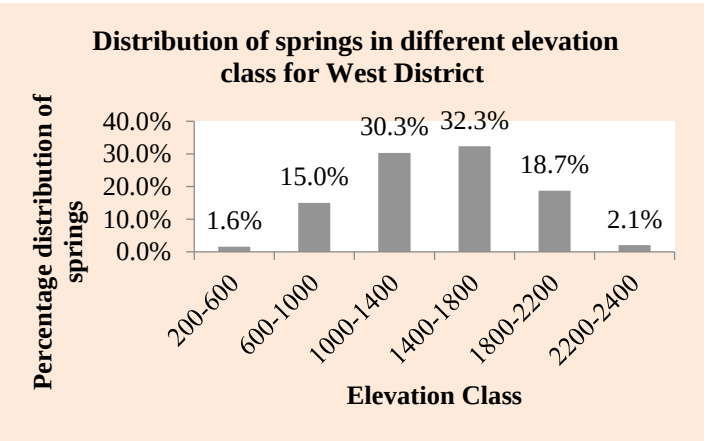
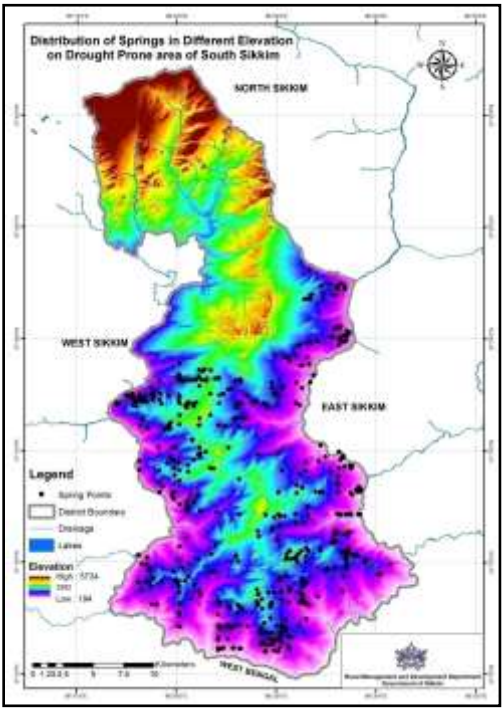


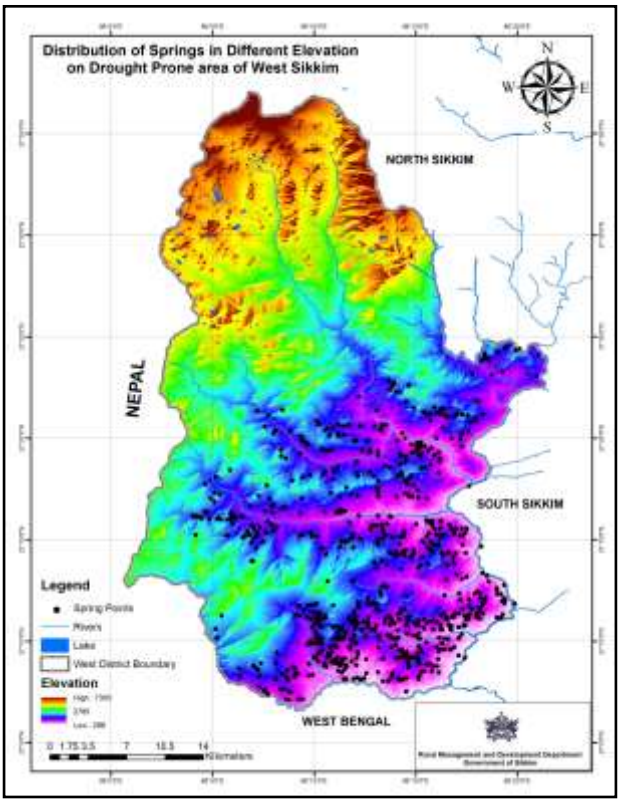
Fig 4: Distribution of springs in different elevation classes for the south district

Fig 5: Map showing the distribution of springs in different elevation classes for the west district



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 6: Map showing the distribution of springs in different elevation classes for the South District



Distribution of springs in different Land use Categories

The distribution of spring points was also analyzed over different land use categories. It is found that more than 48% of the springs in the south district are found over agricultural fields (Fig 7 & 9). This may be because agriculture was practised considering the accessibility to the water sources. However, the dominant agriculture is dry mountain farming dependent on rainfall. Similarly, about 36% of the springs are located in forest areas and 11.6% of springs are found in tree clant areas. Tree clant areas are vegetated areas within the agricultural fields or drainage lines. About 90% of the south district falls on the rains shadow area of Darjeeling hills.

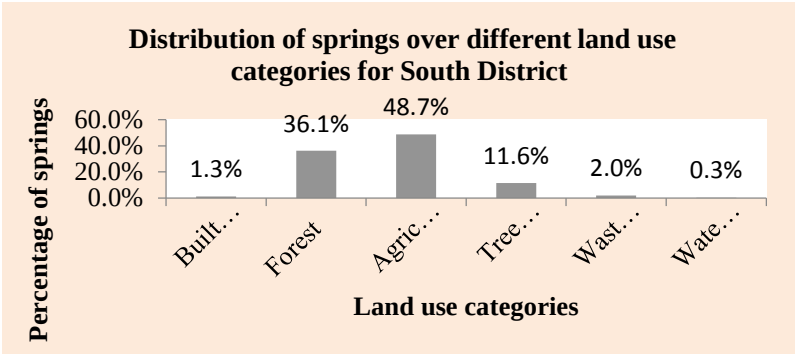


Fig 7: Percentage distribution of springs over different land-use categories in the south district

The data analysis for the west district shows that more than 59% of springs are located in agricultural fields (Fig 8 &10). 33 % of springs are located in forest cover and 6.7 % of springs are found in tree clant areas. Compared to the south district the percentage of springs located in the agriculture area is more in the west district. Most of the lower slopes practice irrigated farming paddy in mid and lower slopes. With the greater density of springs and ensured soil moisture most of the higher slopes are dominated by cardamom cultivation.

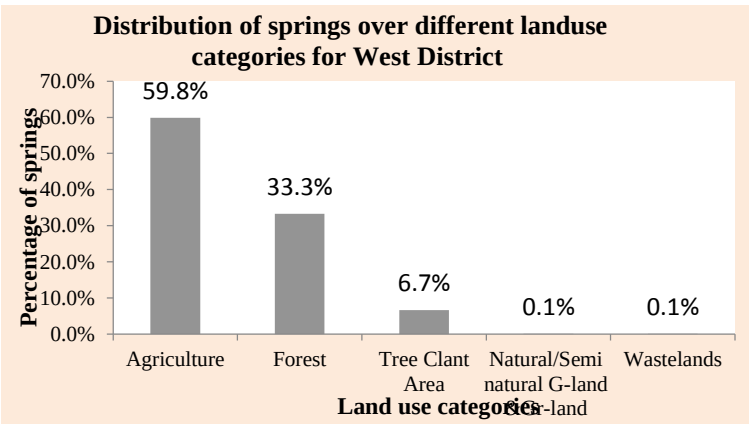
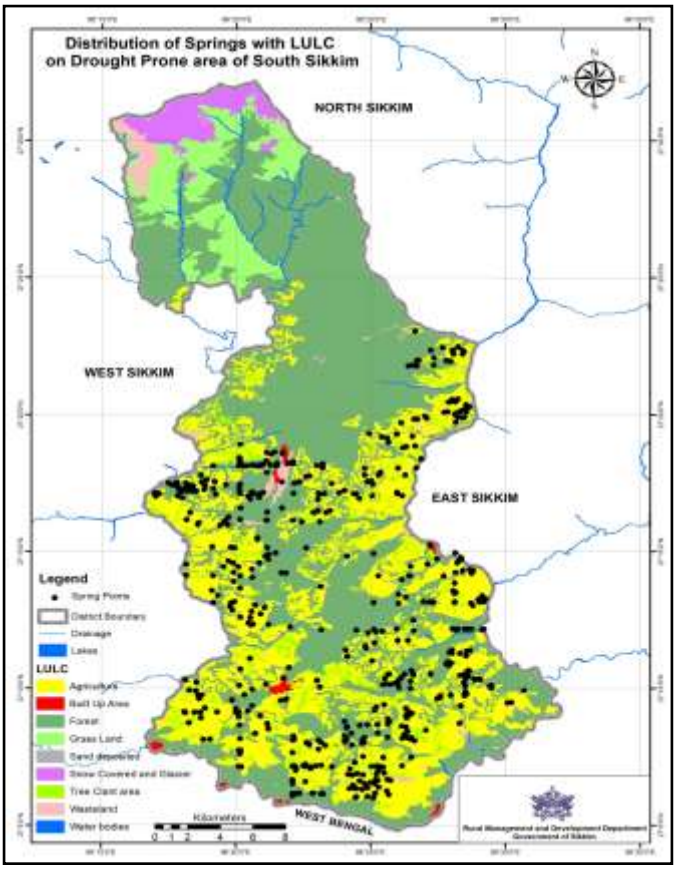


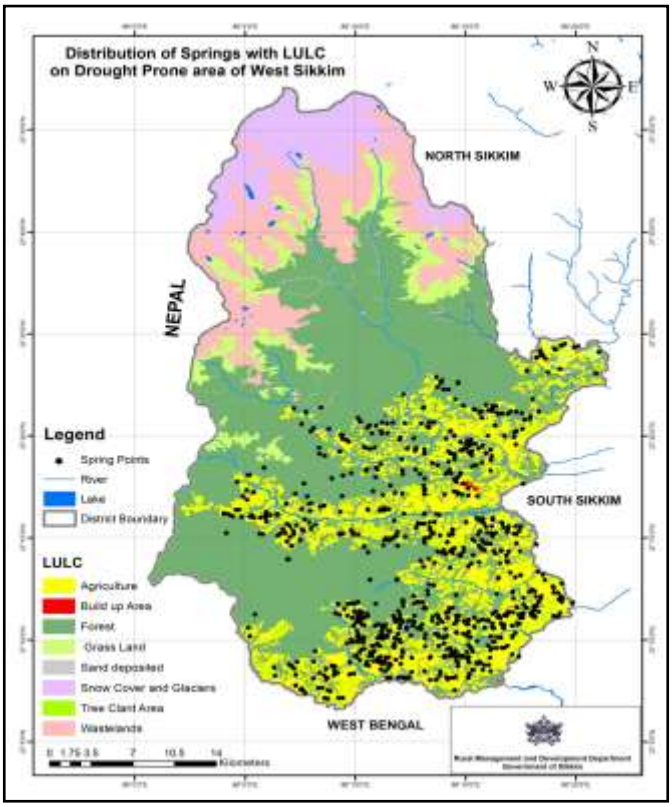
Fig 8: Percentage distribution of springs over different land-use categories in the south district

Fig 9: Map showing the distribution of springs with land use and land cover for the south district



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 10: Map showing the distribution of springs with land use and land cover for the west district



Distribution of springs in different slope categories

The analysis of spring points over different slope classes for the south district shows that about 48% of springs are found in areas having 20 to 40 degrees slope, 23% of springs are found in slope class 30 -40 degrees and 19% of springs in slope class 10 to 20 degrees(Fig 11 & 13). More than 80 % of springs are located between 10 degrees to 40 degrees slope.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

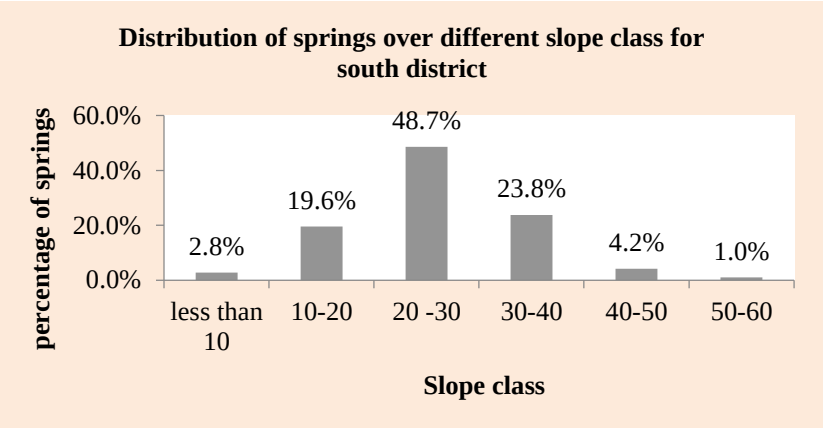


Fig 11: Percentage distribution of springs over different categories of slope in the south district

The data analysis for the west district shows almost similar results wherein45% of springs are found in the slope class 20 -30 degrees, 24% of springs are located in slope class 30-40 degrees and 22 % of springs are found in areas having 10 -20 degrees slope (Fig 12 & 14). Less than 3 % of springs are found in slopes less than 10 degrees or above 50 degrees in both districts.

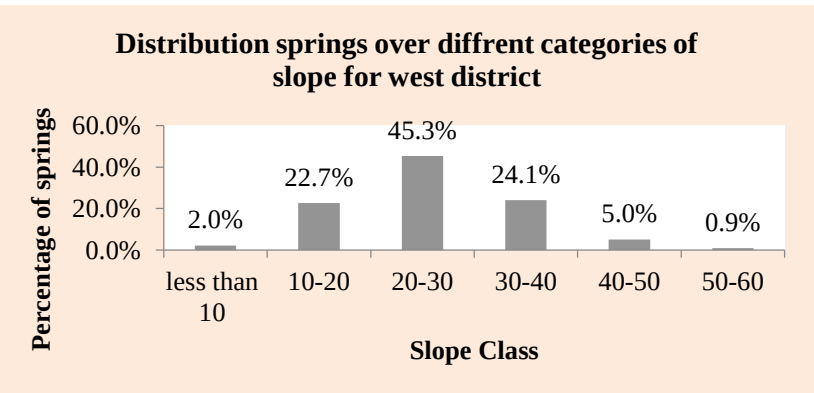
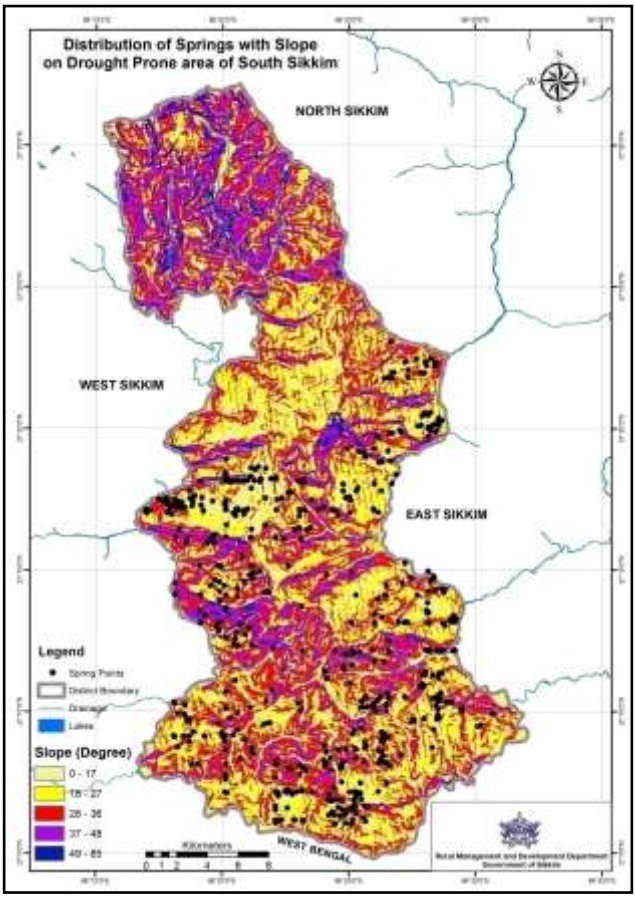


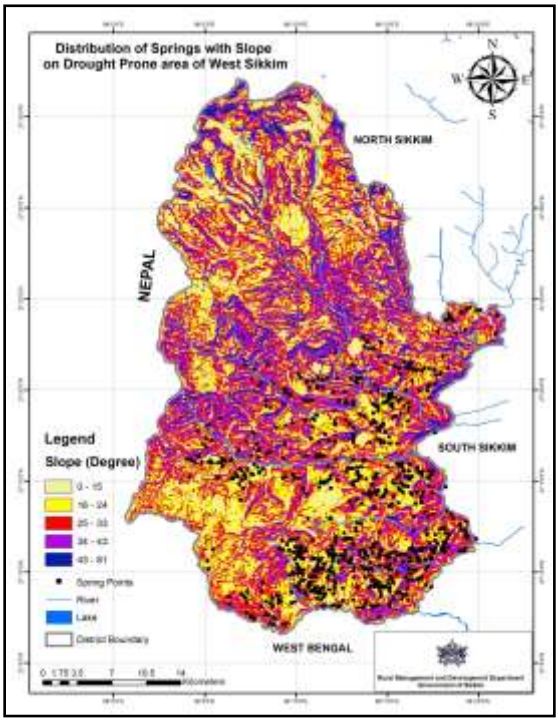
Fig 12: Percentage distribution of springs over different categories of slope in the west district

Fig 13: Map showing the distribution of springs with slope class for the south district



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 14: Map showing the distribution of springs with slope class for the west district



Distribution of springs on different Aspects

Analysis of spring points concerning the aspect for the south district shows that 18.7 % of the springs are situated in the north-west aspect, 15.9 % of the springs towards the south, 12.9% towards the east, 12.8%, 11.3% and 10.7 towards the south-east, south-west and west aspect (Fig 15 & 17). Similarly, 18.2 % of Springs in the west district follow the south-east aspect, 15.7% south, 14.5% north, 13.5% north-east, 12.2 south-west and so on (Fig 16 & 18). This show that springs are more structurally controlled and aspect has no or very little influence on the distribution of springs which warrants more detailed investigation.

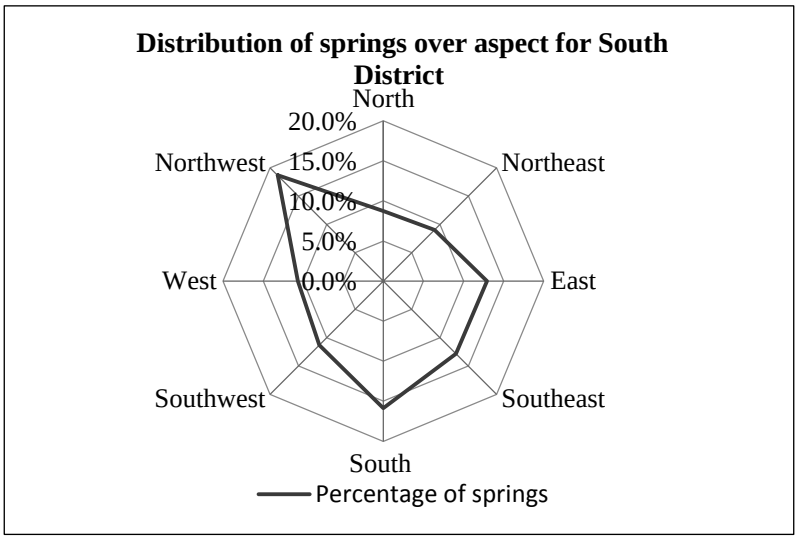


Fig 15: Percentage distribution of springs over different aspect categories for the south district

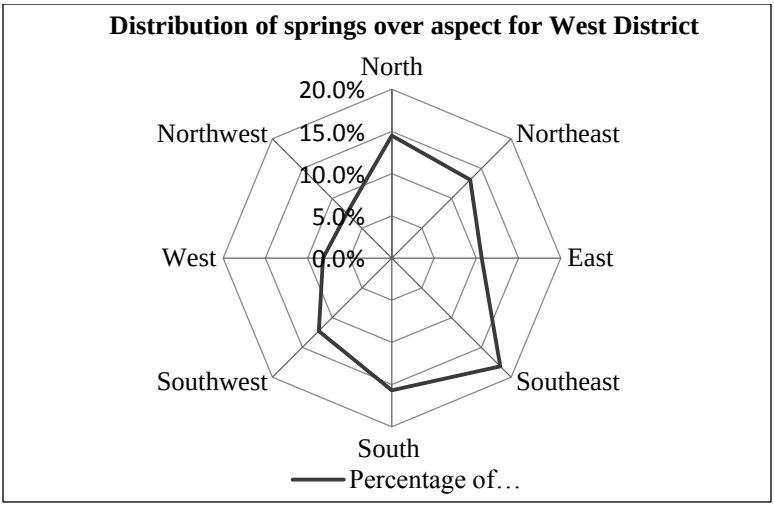
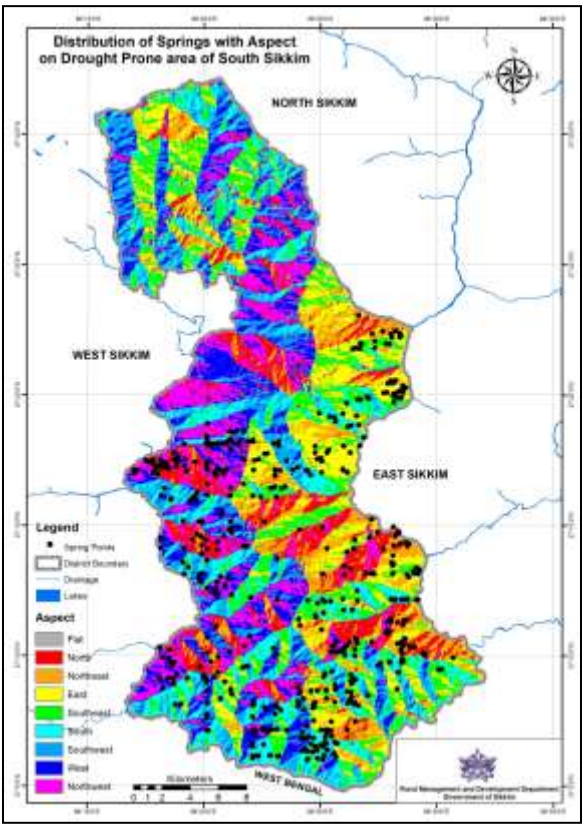


Fig 16: Percentage distribution of springs over different aspect categories for the west district

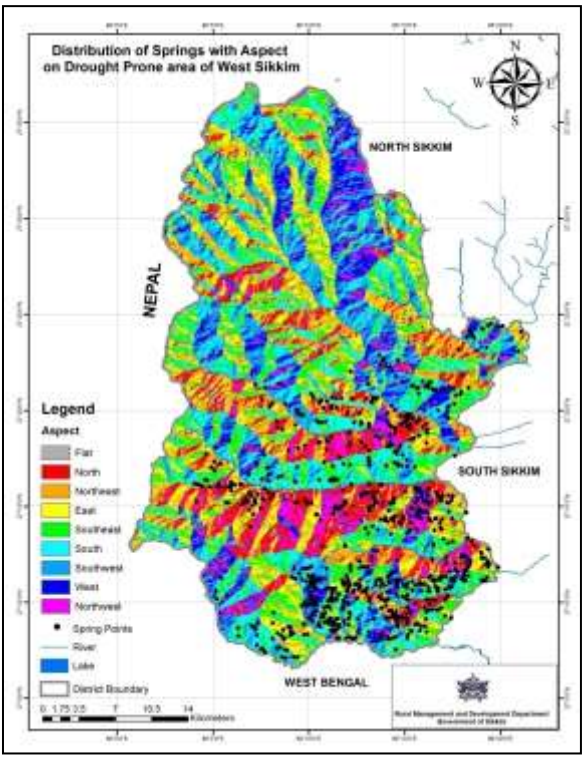
ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 17: Map showing the distribution of springs on the aspect for the south district



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 18: Map showing the distribution of springs on the aspect for the south district



Distribution of springs over different types of forest in the South District

Analysis of spring points in different types of forest in the south district shows that 40 % of the springs are found in subtropical wet hill forests, 35 % of the springs were distributed over a non-forested area, 9 % of springs are distributed over the mixed deciduous forest (Fig 19 & 21). Similarly in the western district, 42.8 % of springs are found in sub-tropical wet hill forests, 38.3 % of springs are distributed in non-forested areas, and 9.7 % in wet temperate forests (Fig 20 & 22).

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

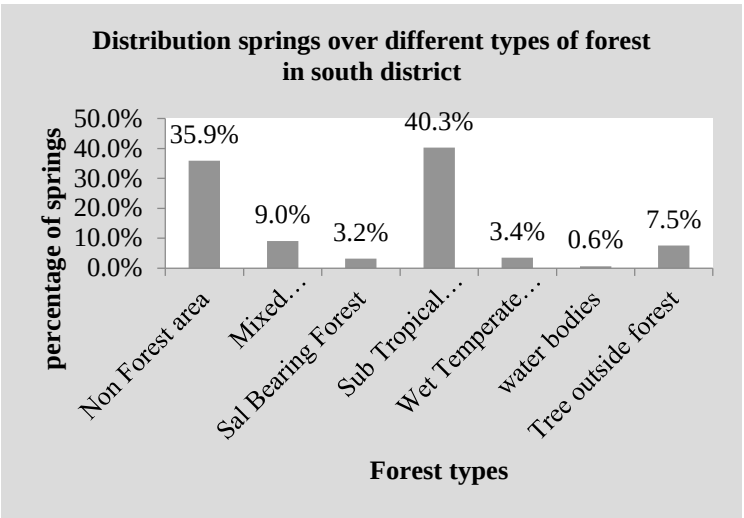


Fig 19: Distribution of springs over different forest types in the south district

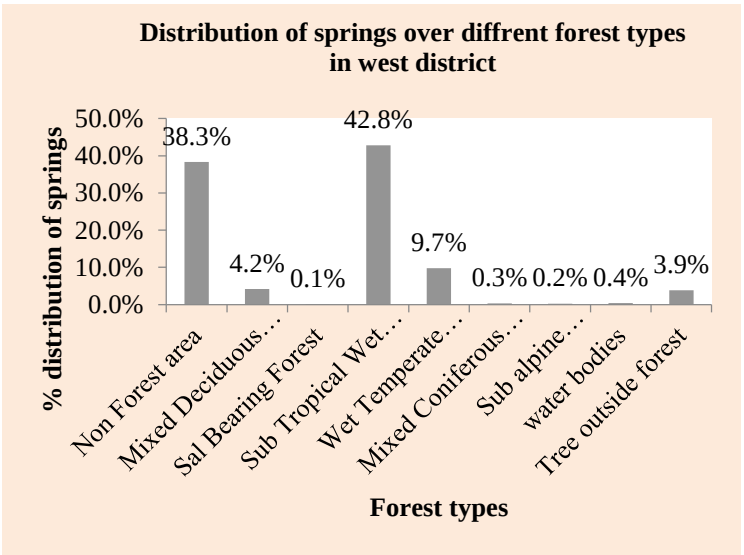
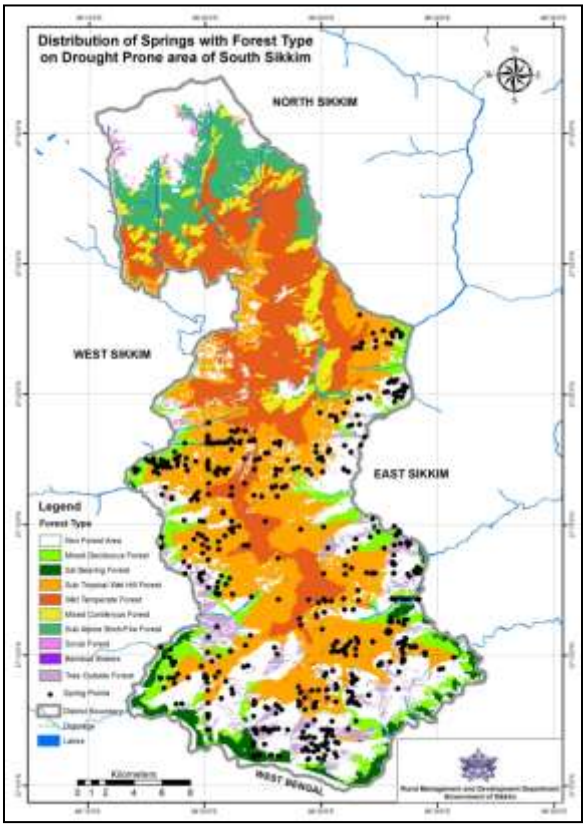


Fig 19: Distribution of springs over different forest types in the west district

In the Mid-mountain region of the Himalayas, Subtropical forests lie between the altitude of 900-1800 m, comprising tree species of Macaranga, Schima, Eugenia, Sapium, Castanopsis and these are generally mixed with shrubby species of Baliospermum, Clerodendrum and Emblica. Beyond 1800 m the vegetation is replaced by wet temperate forests wherein the dominant species are Suaga (Hemlock), Acer, Michelia, Juglans, Rhododendron and Quercus (Oak). These species are said to develop

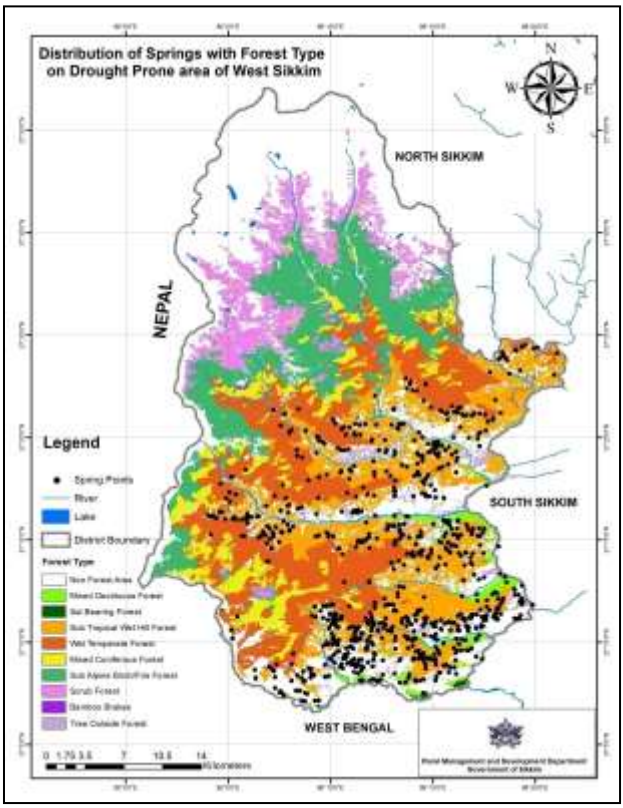
very conducive forest floors for water recharge mostly on the non-snowing hilltops and ranges of mid-mountain regions (Singh and Rawat, 1985). The presence of the springs in non-forested or agricultural areas is due to human settlement around the wet point or water sources.

Fig 20: Map showing the distribution of springs over different types of forest for the south district



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Fig 21: Map showing the distribution of springs over different types of forest for the west district



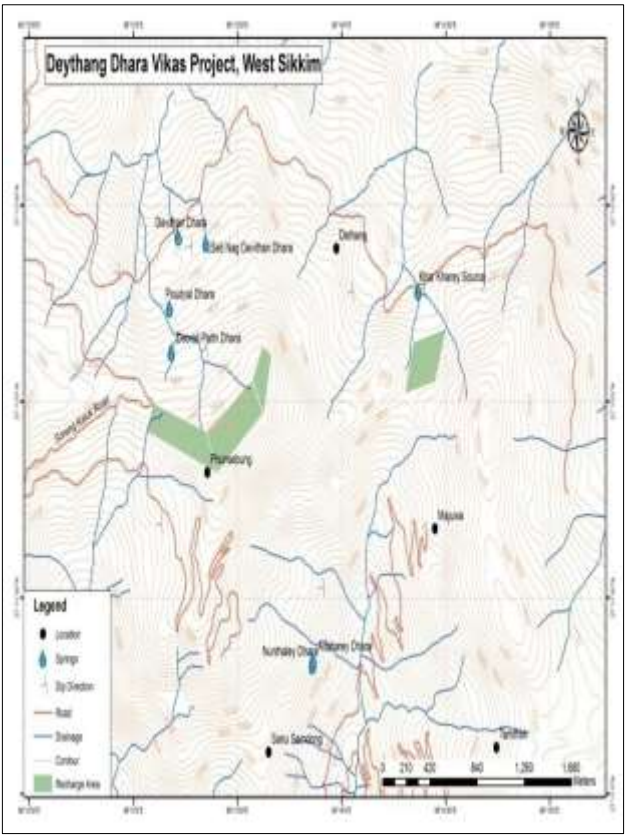
Deythang, Dhara-Vikas project West Sikkim

Physiographic Setting

The project area in Deythang, West Sikkim is located at 88^0 12' 30" E to 88^0 15' 30" E Longitude and 27^0 11' 00" N to 27^0 13' 00" N latitude. The area falls in the mid-mountain category and forms the headwaters of the Reshi Khola watershed. The elevation ranges between 980 m to 2060 m ASL. The relative relief of the project area is 1140 m. The drainage density is 0.21 Km/Km^2. The Soil depth is deep to moderately shallow characterized by severe soil erosion. The soil colour is brown to dark yellowish brown. The texture is silt loam to loam and strongly acidic in reaction marginally suitable to rice and moderately suitable to maize. The project area is characterized by a radial drainage pattern mostly with 1^{st} to 3^{rd}-order drainage radiating in all directions from NE to SW running the Phunsebong RF range. Most of the first-order drainage originating at the altitude between 1500 to 1800 ASL originates from the springs.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Figure 22: Contour map of Deythang Dhara Vikas site

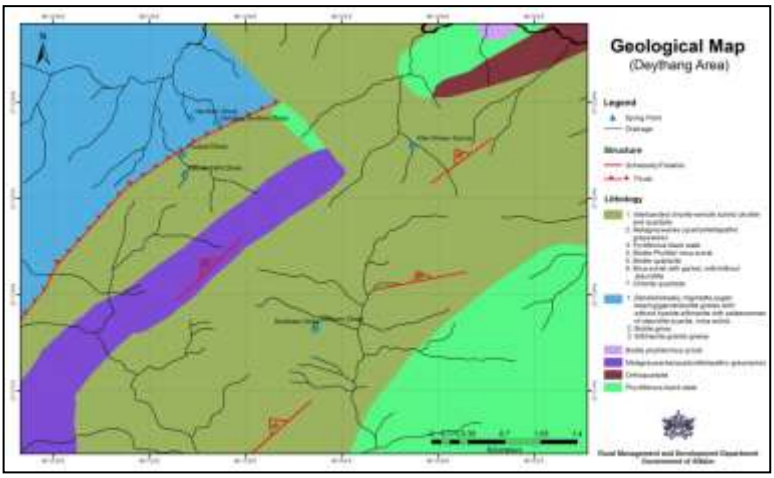


Geology:

The northwestern part of the project area is characterized by the rock formation of the Dalling group with Kanchendzonga/ Darjeeling Gneiss underlain by the Gorubathan formation mainly characterized by interbedded phyllite and quartzite (foliation dip 50^0 to 55^0 NW) intruded by the band of metagraywacke of Reyong formation with foliation dip of 35^0 NW. The Southeast and parts of the northeast are characterized by the rocks of Reyong formation mainly slate in the south-east and Orthoquartzite and Metagreywack of Reyong formation. The main central thrust line (MCT) between the Gurubathan formation and overlying Darjeeling Gneiss can be identified in NE to SW direction making NW-SE fault line. Vertical fractures are developed along the major streamline in all directions on the Gurubathan formation from the Phusebong RF ridge which forms the spring-fed perennial drainage downstream. The geological map superimposed with the drainage line at the scale of 1:50,000 is given in Figure 23 below.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Figure 23: Geological map of Deythang Dhara Vikas site



Intervention and Results

Pilot spring-shed development works were undertaken for the three critical fracture springs namely Nunthaley Dhara, Aitbarey Dhara and Kharkharey Kholsa which were becoming seasonal. With the help of a trained para-hydrogeologist, a total of 40 hectares of spring-shed development work was taken up in the catchment area of these springs in the year 2011. The identified recharge as per the hydrogeology of the area is given in Figure 21. The total investment in this pilot program was about Rs 9.7 lakh, amounting to Rs 3.34 lakh per spring. During the first phase, rainwater recharge structures were developed in 5 hectares of identified recharge area above each spring. Groundwater recharge structures such as staggered contour trenches, percolation pits, check dams etc. were dug on sloping land not affected by landslides. Wherever farmer's fields were used, the incentive in the form of horticulture and fodder plantation was provided in the second phase. The data analysis for three springs namely Kharkare Kholsa (fig 24), Aitabarey Dhara (fig 25) and Nonthaley Dhara (fig 26) shows that the average lean season discharge (ALD) after the Dharavikas initiative has increased by more than 80% for Kharkhare Kholsha, and more than 70% for Aitabarey and Nonthaley Dharas respectively.

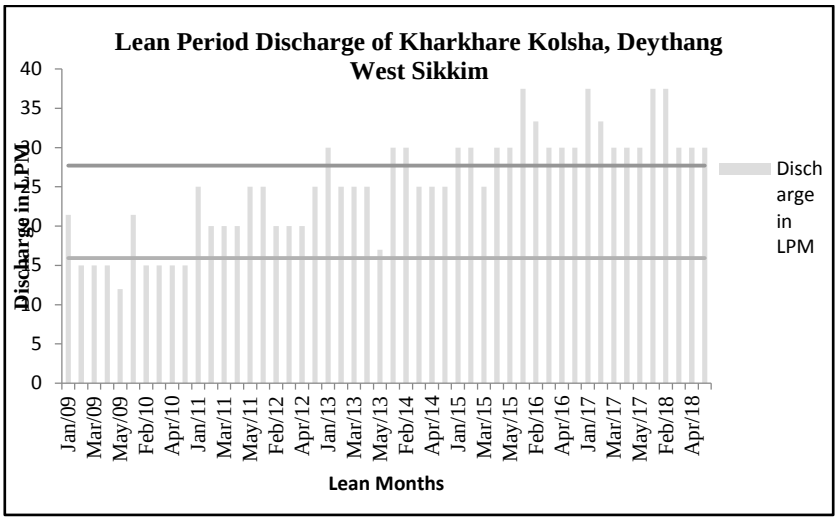


Figure 24: Average lean season discharge before and after the intervention for Kharkhare Khosha

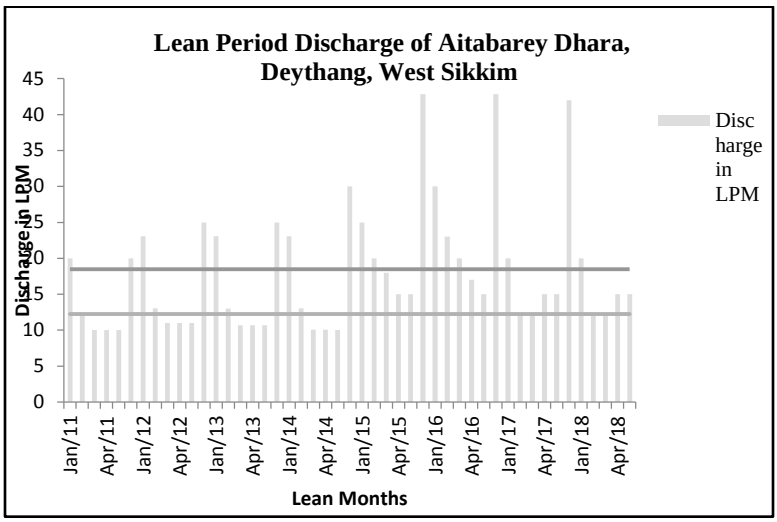


Figure 25: Average lean season discharge before and after the intervention for Aitabarey Dhara

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

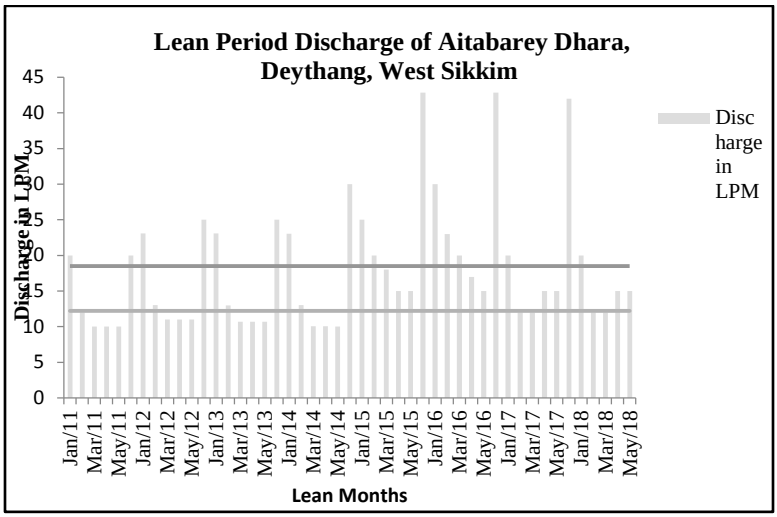


Figure 26: Average lean season discharge before and after the intervention for Nonthaley Dhara Melli, Sadam and Sumbuk groundwater recharge project, South Sikkim

Physiographic setting

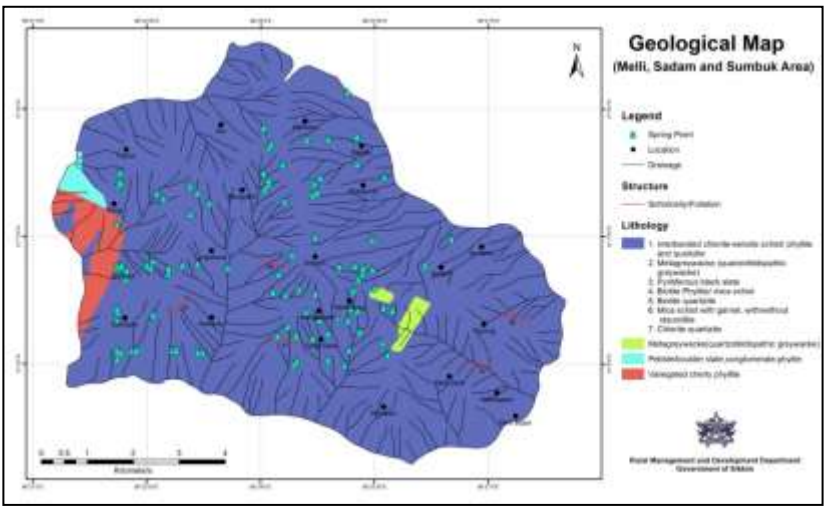
Melli, Sadam and Sumbuk groundwater recharge project area extends from 27^0 04' 47.07" North to 27^0 09' 47.36" North Latitude and 88^0 21' 18.61" East to and 88^0 27' 55.62" East Longitude with an area of 34.8 km^2. Drainage density is 4.06 Km/Km^2. Towards the Southeast, the area is characterized by a maximum slope of 23.3 % and East and West aspects have a maximum slope of 26.6% and 37.5 % respectively. The area forms the Right bank of River Teesta on the eastern side and the left bank of River Rangit on the southern side. The elevation ranges between 215 m on the confluence to 2080 m ASL on the Tamley Chaur ridge. From West to East Tuk Khola (3^{rd} Order), Rolu Khola (4^{th} Order), Hee Khola (3^{rd} Order) and Khani Khola (3^{rd} Order) are the major spring-fed streams draining the south-facing slope which are important sources of water supply for villages of Rong, Sumbuk, Lunchok, Kamerey, Mungram, Sirobari Mangalbare, Ramabong Turuk, Kerabari, Melli and Suntaley. East flowing 2^{nd} and 3^{rd} order streams are a major source of water to Sadam, Suntaley and Rabitar villages. Most of the perennial first-order drainage follows the vertical fractures developed in different aspects of the slope. The drainage lines developed by surface runoff remained dry during the lean season. The area is characterized by dark yellowish brown coarse-loamy, strongly acidic silt loam in foothill areas. The ridges are characterized by dark greyish brown coarse loamy moderately acidic silt loam. The intermediate slopes are characterized by moderate to excessively drained coarse sandy loam. The soils are of moderate productivity.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Geology:

The geology of the Melli Sadam and Sumbuk area is mostly characterized by interbedded phyllite and quartzite patchy exposure of quartzofeldspathic greywacke north of Melli dara and east of Ramabong village of Gorubathan Formation. This is overlain by variegated Cherty Phyllite of Reyong formation west of Sumbuk and south of Rong villages. A small portion of the Pebble/boulder slate conglomerate and phyllite from the Rangit pebble slate group of the Gondwana supergroup are found west of Rong Village. A geological map superimposed with drainage in 1:50,000 scale for the project area is given in Figure 27 below.

Figure 27: Geological map for Melli, Sadam and Sumbuk groundwater recharge project



Intervention and Results

After the hydro-geological assessment of the area, recharge areas were identified mostly over the ridge around the drainage lines following the prominent fractures and the gently sloping exposed portion of the escarpment close to the ridge (fig 27). A total of 100-hectare area was used for treatment in two phases, 80 hectares in Sadam reserve forest and 20 hectares in Mungram Reserve Forest. A total of 10,000 recharge trenches and 2500 ponds were dug in the identified recharge site with 16062 person-days of MGNREGA labour. Households located in the upper belt of Mellidara Gram Panchayat faced acute crises of water during the lean season. The villager transported 4000 litres of water twice a week from the river downstream with an average household cost of Rs. 3200 per month.

Photo 2: Digging artificial staggered trenches to capture rain water in recharge area

Springs in upper Melli Dara have revived and become perennial which has helped the villagers to save Rs. 1.28 lakhs per month. Today more than 60 poultry farms are producing 58000 poultry in 45-50 days. An Impact assessment study conducted by IISc Bangalore in Sumbuk Block in 2013 reported an increase of 10 to 15% in the quantity of water collected from springs for domestic purposes, throughout the year.

Figure 28: Elevation map showing recharge area Melli, Sadam and Sumbuk groundwater recharge project

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

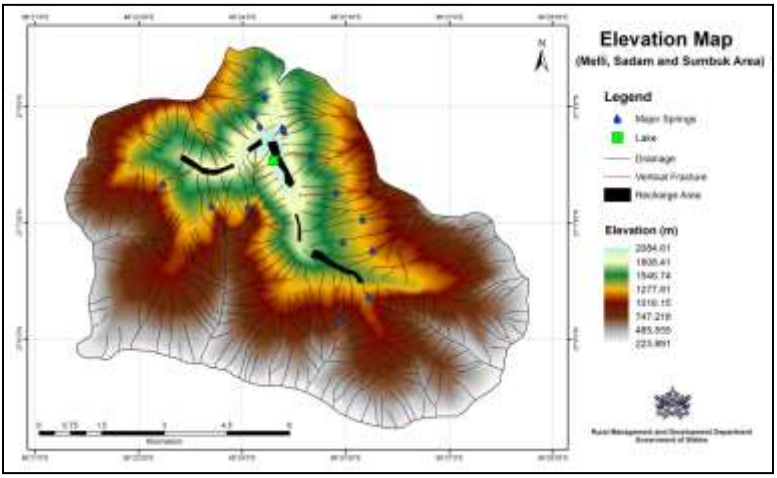


Figure 28. Elevation map for Melli, Sadam and Sumbuk groundwater recharge project

Tendong Hill groundwater project, Namchi South Sikkim

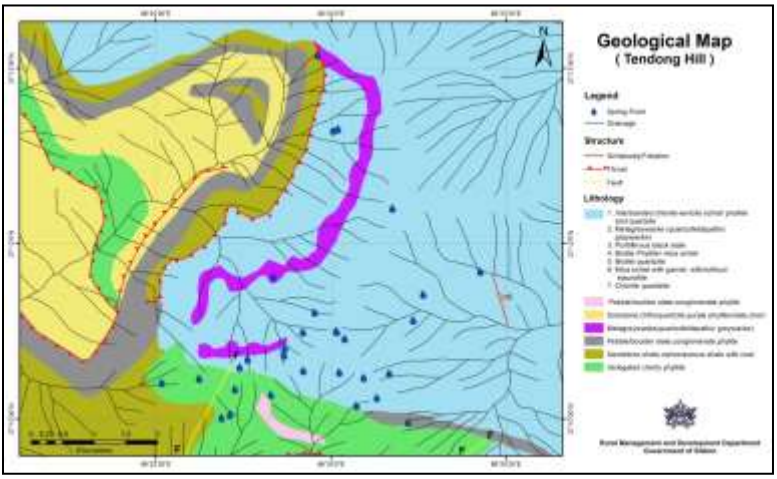
Physiographic setting

The Tendong Hill project area extends from 27^0 09' 45" North to 27^0 14' 00" North latitude and 88^0 20' 00" East to 88^0 24' 30" East Longitude. The elevation ranges from 600 m to 2666 m ASL. Tendong hill range is generally NE – NW running mountain range with Temi Tarku towards the north, Namchi town in the southeast and Perbing village in the east. The average annual rainfall is 160 cm and the drainage density of the area is 3.15 Km/Km^2. The maximum slope towards the East is 41%, the south is 18 %, the west 50% and the north is 45 %. The spring-fed streams originating from the Tendong hills are a major source of water supply for the Namchi town and villages of Jawbari, Damthang, Temitarku, Perbing, Bhanjyang, Kamrang, etc. The area is characterized by dark brown moderately sub-angular loamy soil with moderate permeability and good productivity.

Geology

The superimposed GSI map over the study area suggests that the eastern part of the study area is characterized by an interbedded sequence of phyllite and quartzite of Gurubathan formation from the Daling group. However, the geological complexity increases towards the west with the thrust of the underlying geological sequence from the Gondwana Super Group (Damuda Group followed by Rangit Pebble Slate). The intrusion of the Buxa Formation and Reyong Formation from the Daling Group can be seen following the Gondwana series. The western part of the study area forms the part of the Rangit Window. NE-SW running fault lines can be seen between the Daling and Gondwana Series.

Figure 29: Geological map of the Tendong Hill project



The field visit suggests that the regional dip of the rocks is towards the northeast by an amount of 30-40 degrees. A sandstone-shale sequence is observed at the base of the hill up to an elevation of 1700 m. Some section of the shales which are coal-bearing were noted which were comparatively softer than those found on the top and is also highly weathered. A few springs were observed at the base of the sandstone layer. At elevation higher than 1700m the sequence changes to alternate layers of quartzite and phyllites. Phyllite layers are thick and show some degree of folding. Quartzite dominates with the rise in further elevation and is fractured. Small gneissic exposures are observed on top of the hill at an elevation of around 2500 m. Two fracture trends are persistently observed across the hill, one trending NNE-SSW and the other trending almost ENE-WSW. The genesis of most of the springs emerging in the Tendong hills is related to these two fracture trends.

Intervention and Results

The Tendong Hill groundwater recharge project was implemented in FY 2013-14 over 164 hectares. The technical study for the project was done by ACWADAM Pune, with funding support from GIZ. The work is done at the landscape level with identified 4 catchment areas namely; North of Tendong Hill, the Tendong Hilltop, the Hilltop of Perbing-Khop and the Hilltop above Sangduptse and Upper Phalidara (fig 30). A total of 7000 trenches of 6ft x 3ft x 2ft and 420 water ponds with 10 ft x 10 ft x 2 ft were dug out in identified recharge area.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Photo 3: Artifical recharge structures Tendong Hill

The Project has helped to increase the discharge of springs abutting Tendong Hills. It has helped in off-season vegetable cultivation in a big way. Jaubari, Perbing, Chuba, and Phong Villages are now the major suppliers of vegetables. It is evident from many wayside vegetable shops along Namchi-Damthang and Namchi-Singtam via Phongla and Perbing roads.

Figure 30: Elevation map of Tendong Hill area with identified recharge zones

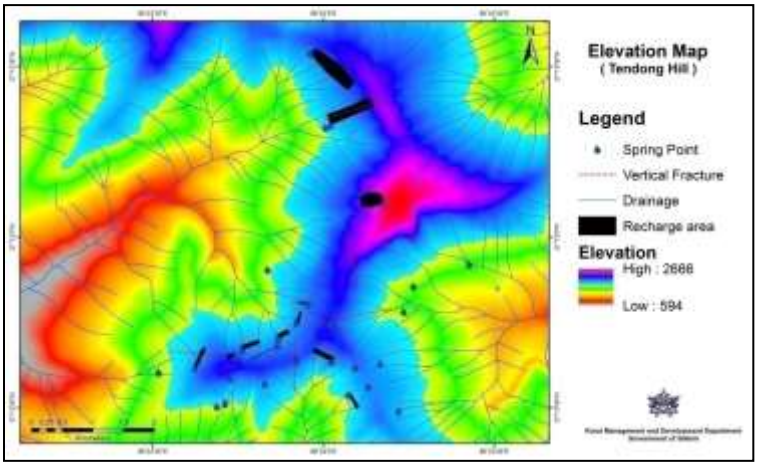
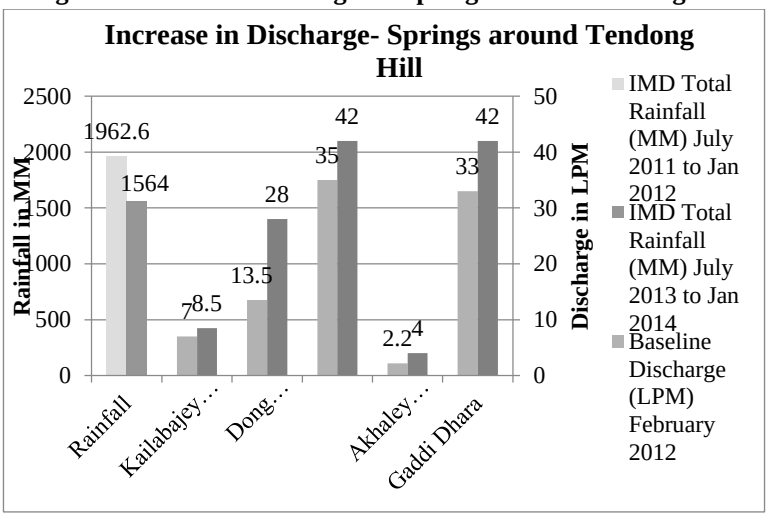


Table 1: Rainfall and Discharge Data Tendong Hill Project

Rainfall /Name of the Springs	Altitude in (m)	Geo-location	IMD Total Rainfall (MM) July 2011 to Jan 2012	Baseline Discharge (LPM) February 2012	IMD Total Rainfall (MM) July 2013 to Jan 2014	Discharge (LPM) February 2014	% increase in discharge
Rainfall (Damthang)	-	-	1962.6	-	1564	-	-
Kailabajey Dhara	1420	N27 10.755 E88 24.952	-	7	-	8.5	21%
Dong Kholsha 2	1924	N27 11.950 E88 24.782	-	13.5	-	28	107%
Dong Kholsha 1	1956	N27 11.989 E88 24.733	-	35	-	42	20%
Akhaley Dhara	1972	N27 11.670 E88 24.268	-	2.2	-	4	82%
Gaddi Dhara	2019	N27 13.428 E88 23.814	-	33	-	42	27%

Fig 31: Increase in discharge for springs around Tendong Hill



Baseline discharge using the bucket method was taken in 2012 for six springs between the altitudes 1420 m to 2019 m ASL in February which is also the leanest month for the springs. The IMD station located at Damthang recorded monthly total rainfall of 1962 mm between July 2011 to Jan 2012 (Six-month rainfall). Dhara Vikas interventions were carried out in the technically identified sites from October to December 2012. Post Dharavikas intervention the discharge data for the same springs were taken during February. The area recorded total monthly rainfall (July 2013 to January 2014) of 1564 mm which was 368 mm less than 2012. However, we could see an increase in discharge of 21% for Kailabajey Dhara, 107% for Dong Kholsha 2, 20% for Dong Kholsha 1, 82% for Akhaley Dhara and 27% for Gaddi Dhara. The varied response of Individual springs to the recharge intervention may be due to the complex geological formation which warrants further investigation.

Emerging results

Inferences from springs mapping suggest that about 80 % of the springs are located between the elevation 600 to 1800 m ASL. Compared to the south district (8.5 %), about 18 % of springs in the west district are located above 1800 m ASL. Increasing the density of springs above the aforementioned elevation range has ensured moisture availability and enabled cardamom plantation in the higher slopes of the west district. More than 50 % of springs are located in agricultural fields. This shows that agriculture was practised around the water sources in the mid-mountain region. More than 80 % of springs are located between the slope class 10 degrees to 40 degrees. Aspect does not play a significant role in the spring point distribution since springs are more structurally controlled. However, an in-depth investigation can be pursued to establish any significant

relationship. Most of the springs emerge in sub-tropical wet hill forests below 1800 m ASl. This has helped to establish that wet temperate forest which spreads above 1800 m ASL in the mid-mountain hilltops and ranges with the dominant species like Oak, hemlock, Acer, Rhododendron etc., seems to be the significant zone of recharge of Himalayan springs. The results from these pilots showed that the springs are fed by groundwater and are recharged by rainwater infiltration. The spring discharge generally showed an annual periodic rhythm suggesting a strong response to rainfall. There is a growing perception that climate change impacts, manifested in the form of rising temperatures, more intense precipitation patterns, and longer winter droughts, have reduced the natural groundwater recharge. The spring revival approach to reviving springs using rainwater harvesting and hydro-geology techniques showed encouraging results, with the lean period discharge increasing substantially. This study showed that the revival of springs was possible by taking up artificial groundwater recharge works in the recharge area (spring-shed) of the aquifer (Tambe et al. 2012). Based on the experiments, an eight-step action plan was designed which provides a step-by-step procedure for reviving Himalayan springs. The scientific aspects of this initiative were communicated using a *spring revival handbook* prepared in comic book style and helped to simplify the science of spring revival. The capacity of local staff was developed and they functioned as para-hydrogeologists assisting in the planning and monitoring of the initiative.

To date, 637 hectares of the area have been covered with Dhara Vikas work. With a total annual rainfall of 150 cm, if only 10% rainfall is intercepted by the recharge structures it is estimated that approximately 955 million litres of water is recharged annually. Similarly, with an average slope of more than 40 degrees, normally more than 85% of the rainfall is lost as surface runoff. Dhara Vikas has been able to control the runoff by 10 to 15% thereby reducing the loss of topsoil from the spring catchment. A case study by TMI India in 2016 on the Sadam Dharavikas project shows that the downstream communities of Mellidara have remarkably benefitted from the enhanced water discharge of the perennial springs. Local communities have started shifting from a traditional system of farming to the diversification of livelihood options in the last five to ten years. Besides traditional agriculture, they have initiated poultry farming, dairy farming, floriculture and cultivation of horticultural crops. 17.6% of households have started poultry farming, out of which 75% have started in the last five years. Consequently, milk production has gone up by 11.6% in the last five years. A dairy cooperative has been established with the support of the Milk Union, Government of Sikkim. The Dharavikas works have enhanced 70% discharge of three springs in Deythang, west Sikkim, There is people's perception that the cardamom plantation has highly benefitted from the works in Deythang. The results from the Tendong landscape project showed an increase in lean season discharge from 21% to 107 % for 5 springs abutting the Tendong range. This has

remarkably helped in the enhancement of off-season vegetables in the Sadam, Jawbari and Perbing areas. The lack of automated short-interval spring discharge data for a longer period has been a major setback of the initiative. The department has commissioned more technical studies with Geo Physical investigations and automated data sets in days to come. This will surely help us to understand the nature and characteristics of Himalayan springs and their aquifer characteristics.

References:

1. Agarwal A, Agrawal NK, Nema RK. 2014. Lifeline: The springs of Uttarakhand, India. International Journal of Innovative Research in Science, Engineering and Technology 3(4):11553–11560.
2. Agarwal A, Agrawal NK, Nema RK. 2014. Lifeline: The springs of Uttarakhand, India. International Journal of Innovative Research in Science, Engineering and Technology 3(4):11553–1156
3. Agarwal A, Agrawal NK, Nema RK. 2014. Lifeline: The springs of Uttarakhand, India. International Journal of Innovative Research in Science, Engineering and Technology 3(4):11553–1156
4. Agarwal A, Agrawal NK, Nema RK. 2014. Lifeline: The springs of Uttarakhand, India. International Journal of Innovative Research in Science, Engineering and Technology 3(4):11553–1156
5. Agarwal, A., Agarwal, N.K., and Nema, R.K.(2014) Lifeline: the springs of Uttarakhand, Indis.International Journal of Innovative Research in Science, Engineering and Technology,3(4), 11553- 11560.
6. Barnett, T. P., Adam, J. C., & Lettenmaier, D. P. (2005). Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature*, *438*(7066), 303.
7. Bruijnzeel, L.A. (2004), Hydrological function of tropical forest: not seeing the soil for trees? Elsevier Journal of Agriculture Ecosystem and Environment, 104,185-228.
8. Chapagain, P. S., Ghimire, M., & Shrestha, S. (2017). Status of natural springs in the Melamchi region of the Nepal Himalayas in the context of climate change. *Environment, Development and Sustainability*, 1-18.
9. Chaudhary, P., & Bawa, K. S. (2011). Local perceptions of climate change validated by scientific evidence in the Himalayas. *Biology Letters*, rsbl20110269.
10. Dhakal, D., Tambe, S., Tiwari, A., Sinha, U.K., Arrawatia, M. (2014) Isotope Studies to Identify the Origin and Recharge Area of Himalayan Springs as a Climate Change Adaptation Initiative: A Case Study from Sikkim, Eastern Himalaya. International Journal of Earth Science and Engineering, 7 (1), 135-140
11. Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science*, *328*(5984), 1382-1385.
12. IPCC (Intergovernmental Panel on Climate Change). 2007. Climate change 2007: impacts, adaptation and vulnerability. Pages 470–506 in M. Parry, et al. editors. Contribution of Working Group II to the Fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

13. Kumar, V., & Sen, S. (2018). Analysis of Spring Discharge in the Lesser Himalayas: A Case Study of Mathamali Spring, Aglar Watershed, Uttarakhand. In *Water Resources Management* (pp. 321-338). Springer, Singapore.
14. Magna, M. (2001), Using springs to study groundwater flow and active geologic processes.Annu.Rev.Earth Planet. Sci., 29, 201-228.
15. Merz, J., Nakarmi, G., & Weingartner, T, (2003) Potential solutions to water scarcity in the rural watersheds of Nepal's middle Himalayas.Mountain Research and Development, 23(1),13-18
16. Myers, M. (1993) Tropical moist forest: overexploited or underutilized? For. Ecol.Manage.,6, 59-79
17. Negi, G.C., and Joshi, V. (1996), Geohydrology of springs in a mountain watershed: the need for problem-solving research. Current Science, 71(10), 772-776.
18. Negi, G.C.S., Rikhari, H.C ., and Garkoti, S.C . (1998), Hydrology of three high altitude forests in central Himalaya, India. A reconnaissance study, Hydrol. Processes, 12,343-350
19. Negi, G.C.S., Kumar, K., Panda, Y.S., and Satyal, G.S. (2001), water yield and water quality of some aquifers in the Himalayas. International Journal of Ecology and Environmental Science, 27, 55-59.
20. Negi, C.S.G., & Joshi, V, (2004), Rainfall and spring discharge patterns in two small drainages in western Himalayan mountains, India. The Environmentalist, 24, 19-28.
21. Negi, G.C.S., Joshi, V., Nayal, M., and Sati, M. (2008), Geohydrological study for augmentation of spring discharge in the western Himalayas. Final technical report, NoWR, GoI.
22. Poudel, D. D., & Duex, T. W. (2017). Vanishing Springs in Nepalese Mountains: Assessment of Water Sources, Farmers' Perceptions, and Climate Change Adaptation. *Mountain Research and Development*, *37*(1), 35-46.
23. Rai, R.N., Singh K.A., and Solanki, R.C. (1998), a Case study of water flows of some hill springs of Sikkim. Indian Journal of Soil Science, 16(1), 52-56.
24. Sharp, D., and Sharp, T. (1982) The desertification of Asia. Asia 20001, 40-42.
25. Sharma, G. (2016) Spring rejuvenation and its Socio-economic impacts of "Dhara Vikas" initiative in rain shadow areas of South Sikkim. Final report submitted to NABARD, Mumbai by TMI India.
26. Spears, J. (1982) Rehabilitating watersheds. Finance Development, 19, 30-33.
27. Singh, A.K., and Rawat, D.S. (1985), Depletion of Oak forest threatening springs: an exploratory study. The National Geographical Journal of India
28. Shrestha, U. B., Gautam, S., & Bawa, K. S. (2012). Widespread climate change in the Himalayas and associated changes in local ecosystems. *PLoS One*, *7*(5), e36741.
29. Tambe, S., M. L. Arrawatia, N. T. Bhutia, and B. Swaroop. (2011). Rapid, cost-effective and high-resolution assessment of the climate-related vulnerability of rural communities of Sikkim Himalaya, India. *Current Science* 101(2):165–173.
30. Tambe, S., Kharel, G., Arrawatia, M. L., Kulkarni, H., Mahamuni, K., & Ganeriwala, A. K. (2012). Reviving dying springs: climate change adaptation experiments from the Sikkim Himalaya. *Mountain Research and Development*, *32*(1), 62-72.

31. Valdiya, K.S., Bartarya, S.K. (1989) Diminishing Discharges of mountain springs in a part of the Kumoun Himalaya, India. Current Science, 58, 417-426.
32. Valdiya, K.S., and Bartarya, S.K. (1991) Hydrological study of springs in the catchment of Gaula River, Kumoun Lesser Himalaya, India. Mountain Resources and Development, 11(3), 239-258
33. Vashist, A.K., & Sharma H.C. (2007), Study of Hydrological behavior of a natural spring. Current Science, 93(6), Communications, 837-840.

Multi-Criteria Land Suitability Analysis for Agriculture in Semi-Arid Region of Tirora Tehsil, Middle India: Geospatial Approaches

Dr. Sharad A. Borude
Associate Professor,
Department of Geography,
Ahmednagar College, Ahmednagar
Email: sharadborude@gmail.com
Nanabhau Kudnar
Assistant Professor, Department of Geography, **C**. J. Patel College, Tirora, Dist. Gondia 441911Maharashtra, India.
Email: nanabhaukudnar@gmail.com
Vasudeo Salunke
Associate Professor, Department of Geography, K. J. Somiya College, Kopargaon, Dist. Ahmednagar, Maharashtra, India
Email: vasusaluke@yahoo.co.in

Article DOI Link: https://zenodo.org/records/10559085
DOI: 10.5281/zenodo.10559085

Abstract:

Based on the geographic modeling of environment factors with suitable weights in GIS, separate environmental resource units have been established in the current study. In the tehsil, thirteen landform units have been discovered. The slope covered roughly 63.76% of the tehsil and ranged from level to almost level. The area was suitable for recreation on very mild to rather steep slopes. In the tehsil's eastern and southeast regions, structural hills and ridges are more prevalent than denudation. As a result of crystalline metamorphic and igneous rocks weathering, the tehsil's soils are extremely diverse. The Kali, Kankar, Morand, Khardi, Sahar, and Bardi soil types are the principal ones. The study shows how geospatial modeling may be used to prioritize locations for land resource management that is sustainable. The current study outlines the procedure for using Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS) techniques to assess the various environmental factors of Tirora tehsil. In the future, the data may be applied to hydrological, restoration, and conservation studies pertaining to natural resources.

Keywords: Geospatial Modeling, Environmental Resources, RS, GIS.

Introduction:

Assessing human carrying capacity is made possible by the village administrativ e unit's preparation of land resources and creation of GIS information on land resources a nd crop output.

Nevertheless, the local government frequently finds it challenging to carry out the resour ce management plans one tehsil at a time. Thus, setting priorities (Dongare, et al 2013; Bhagat, 2012, 2014; Biswas et al, 1999; Gaikwad & Bhagat, 2018; Pathare and Pathare 2020; Khan, et al 2001; Javed, et al, 2009) plays a key role in the identification of critical areas based on the assessment of human carrying capacity in the management of land resources on a sustainable basis. Geospatial modeling in GIS enables the integration of the environmental resources, crop production and consumption scenarios (Chattaraj, et al, 2017; Engelhardt et al, 2012; Forzieri et al, 2008). The introduction of contemporary geospatial technologies, such as Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS), has made it possible to conduct surveys, identify, categorize, map, monitor, and characterize a variety of earth resources, both living and non-living, and to track changes in their composition, extent, and distribution. In addition to supplying geo-information in a spatial manner, remote sensing (RS) is crucial for assessing, improving, and keeping track of the earth's total capacity. Protecting the environment globally, lowering the cost of disasters, and attaining sustainable development now depend heavily on satellite observations of the land, oceans, and atmosphere, particularly during natural and human-induced hazards. (Ahmed & Pandey, 2018; Ali et al, 2017; Bagat & Bisen, 2015; Kudnar, 2020a,b).

GPS offers precise positional data all across the world, making it helpful for determining location and context. GPS is a valuable technology for monitoring purposes as it provides a cost-effective means of obtaining up-to-date in-situ data by repeatedly gathering information on earthly features and events (Howard, 1990; Reddy, 2018; Mark, 1983; Kadam, et al, 2020; Kudnar et al 2022; Kudnar and Rajashekhar, 2023). GIS helps in visualization of geospatial data, and the visualization is a convenient and effective way to communicate complex information, e.g. natural resource, and increase our level of understanding about these resources (Siddi, et al, 2018; Kudnar, 2022; Kudnar et al 2023)

Delineating distinct geomorphology, soil types, geology, slope, relief, landforms, climate and rainfall, hydrology, water availability analysis, water inflow, water balance, measurement of water discharge, demographics, resource unit assessments, human carrying capacity calculations, and area prioritization through geospatial modeling in GIS have all been attempted in this study with respect to sustainable land resource management in Tirora tehsil of Gondia district, eastern Maharashtra, India.

Study Area:

Tirora tehsil of Gondia district is bounded by North latitudes 21° 13' 05" to 210 33' 30" and East longitudes 790 47' 50" to 800 05' 00" and is located in North-Western part of the district, Maharashtra (**Figure-1**) with the total geographical area of 617.10 Sq.km. The climate of the study area is sub-humid, sub-tropical with well-defined summer (March-May), rainy season (June-October) and mild winter (November-

February) (Kudnar, 2015a). The mean annual temperature is 26.40C with a mean maximum of 29.30C and a mean minimum of 24.120C. The mean annual precipitation of the tehsil is 1400 mm of which nearly 85% is received during the south-west monsoon period (June-October). Wainganga river flows from north to south in the western part of the tehsil forms a major drainage system having the lower elevation ranges from 240 to 280 above MSL, whereas, the higher elevation ranges from 350 to 500 above MSL (Kudnar, 2015b).

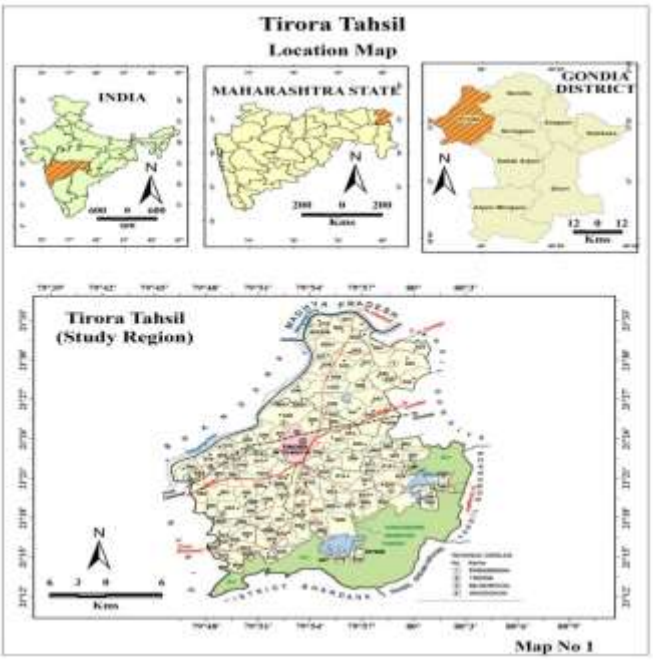


Figure 1. Location Map of the Tirora Tehsil

Methodology:

This work is grounded in a field investigation. For a thorough environmental analysis, different topographical sheets are examined in addition to general field observations. An environmental analysis of the Tirora tehsil was conducted on a 1:50,000 scale using the topographical maps provided by SOI. The tehsil's environmental network was examined, along with the geomorphic unit, geology, land use, soil, and water analysis, among other topics. With ArcGIS desktop 9.3, SOI topographic maps were georeferenced using the WGS 84 datum and the Universal Transverse Mercator (UTM) zone 44N projection. In this study, a database was created and a number of drainage metrics were extracted by the combined use of multispectral satellite data, Cartosat Relief, and SOI toposheets. Cartosat (1 arc second) was used in this study together with GPS position, SOI toposheets, river hydrology (Horton, 1932), rainfall,

water availability, and discharge data to outline the Tirora tehsil and extract the geomorphic unit. Kudnar and Rajashekhar (2020) collected water samples from the downstream and upstream of the TTPP's water intake well at the Wainganga River. The environmental factors that were examined included geomorphology, soil types, geology, slope, relief, landforms, climate, rainfall, hydrology, water availability analysis, water inflow and balance, measurement of water discharge, demographics, and land resource management prioritization (**Figure 2**).

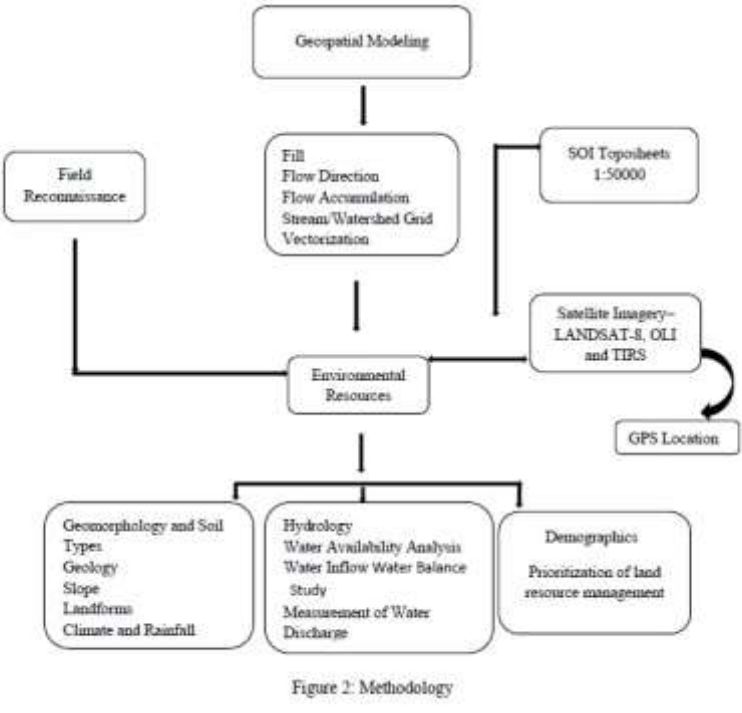


Figure 2: Methodology

Results And Discussion:

Geomorphology and Soil Types:

The Denudation Origin, which is the mechanical basis, and the one governed by differential weathering. The tahsil's eastern (Mundikota area 21.3696 N 79.8360 E) and southeast (Chorkhamara area 21.2666 N, 79.9557 E) regions are more likely to have structural hills and ridges, whereas the denudational areas, which include the Gangazari (21044'86" N 80005'72'E), Bodalkasa (21035'06" N 80001'93'E), and Sukadi (21035'19"

N 79097'95" E), are more likely to have these features. The tehsil has an undulating landscape with heights ranging from 263 to 315 m MSL and is a part of the Wainganga sub-basin. Physically (**Figure 3**), the tehsil can be roughly split into two physiographic units: the one governed by structural features, where the tehsil's highly diverse soils are produced by the weathering of igneous and metamorphic crystalline rocks. The Kali, Kankar, Morand, Khardi, Sihar, and Bardi soil types are the principal ones. The primary crop in the district, rice, is grown on Sihar soils; pediments may be found in the north-central, west-central, and south-west regions of the region (**Figure 4**). The riverine plains of the Waingana, which flows southwest, and its main tributary, the Bawanthari, which flows east, are contained within 155 285 m, with the riverbank's height at the Water Intake Well position being 267 m (**Figure 5**). On the southwest border of the research area, this region's low-lying areas are susceptible to flooding during the Wainganga's high-discharge years. The area between 255 and 265 meters, along with the floodplain region (Kale, 1990, 2002; Bhagat & Bisen 2015; Kudnar, 2018), make up a fertile, flattish plain that is widely used for the cultivation of vegetables, grains, and pulses. The research region has a relative relief value of 145 meters due to the height reaching up to 400 meters in the northwest and east. The majority of the region's underlying rocks are of granitic provenance, with some migmatites found at lower elevations and mica-schists and phyllites found at higher altitudes in the west. Quartzite exposures are also observed. The Wainganga Valley's center and floodplains are covered in alluviums. The Wainganga System valley and the remnant hill outliers on the periphery dominate the area. According to Kudnar (2019), the riverbank at the water's location is 267 meters above sea level.

Geology:

The Tirora tehsil area is distinguished geologically by rock strata ranging from pre-Cambrian granite and gneiss to more modern alluvium. The three types of gneisses are magnetite, hornblende gneiss, and biotite. The region is heavily metamorphosed and part of the Archean sediments preserved in the synclinal depressions of the terrain. Younger metamorphosed sedimentary strata are housed in the basement formed by the composite Biotitic gneiss. The region is home to two different types of rock series: the Sakoli Formation and the Sausar Series. Particularly in the Tirora region, the research area is part of the Sausar series. The lithological Sausar series is made up of hornblende schist, mica, and talc granulites. The Sausar group's gneiss rocks include biotitic but not chlorite. These rocks are connected with manganese deposits. The rocks are composed of low-grade metamorphoses, including quartzite, kyanite sillimanite, muscovite and hornblende schist, and chlorites and phyllites. Quartz veins and simple rocks are intruding them. Alluvial cover ranging in thickness from a few meters to fifteen meters has been seen along the Wainganga River's bank.

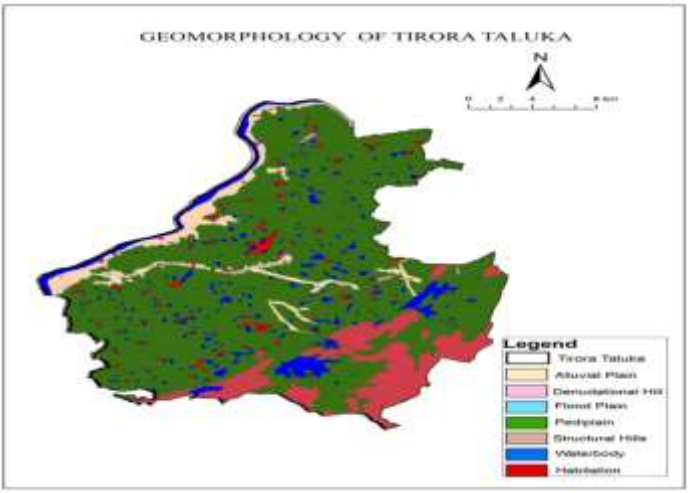


Figure 3. Geomorphology

Slope:

The results of the slope analysis indicate that the total geographical area (TGA) is approximately 65.15 percent made up of level to nearly level slopes (0 - 1 %), very gentle slopes (1 - 3 %), gentle (3 - 8 %), moderate slopes (8 – 15 %), moderately steep slopes (15 - 30 %), steep slopes (30 - 50 %), and very steep slopes (> 50 %). 6.60 percent of TGA is made up of communities and bodies of water (**Figure 5**).

Figure 4. Soil

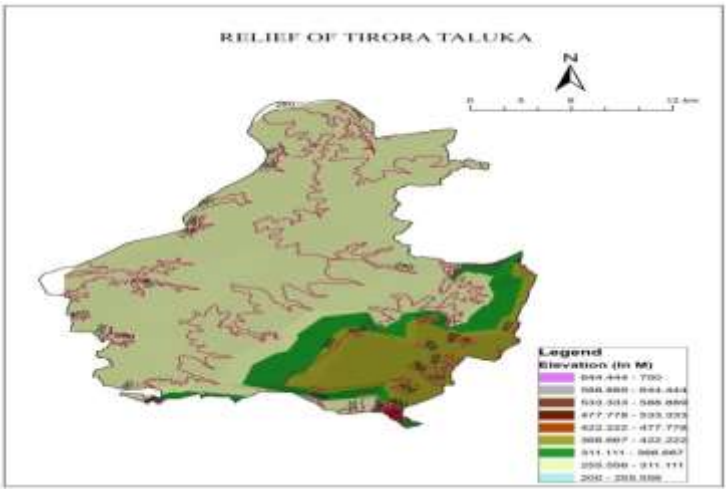


Figure 5. Relief

Landforms:

Dissected hilltops Nagzira ranges (21.2844 N to 79.9468 E), dissected hills Bodalkasa ranges area (21.3262 N to 80.0260 E), subdued hills Nimgaon ranges (21.3936 N to 80.0402 E) and residual hills surrounding Tirora, Karati, Indora area are characterized by various fluvial erosional activities and associated with granite gneisses formations mainly in eastern and southeastern parts of the study area. Isolated mounds and linear ridges are sinuous, narrow, highly disintegrated by mechanical weathering processes and are remnants of the land reduction process. Shallow, moderate and deeply weathered pediments are low in relief and are associated with granite gneisses formations in the central part of the study area with stratified to semi-stratified fluvial sediments.

Climate and Rainfall

The Climate of the tehsil is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The mean minimum temperature is 6°C and means the maximum temperature is 45°C. The normal annual rainfall (Table 1) over the district ranges from 1300 mm to 1500 mm. It is the minimum in the north-west south-east direction and increases in the north-east direction. Tirora west receives the minimum rainfall of 1357.8 mm while the maximum rainfall of 1415.8 mm is received in the east part. To ascertain the certainty of rainfall that may occur (dependable rainfall), the probability analysis of the rainfall data for the period from 1917 to 2016 is also carried out for different probability levels of 50%, 80%, and 90%. For doing the analysis, daily rainfall data has been converted to the average monthly data. The monthly rainfall data has thereafter been analyzed for different probability levels. The analyzed rainfall results will help in the estimation of river discharge during the lean season, or during various months and

also during the year. Lower probability indicates, less assurance to the occurrence of rainfall, while higher probability indicates, rainfall has more chance to occur. The weighted average monsoon rainfall at different percentage dependability for the Wainganga sub-basin (i.e. Vidarbha Region) has been worked out and calculation for the same are kept. That as the probability increases, the magnitude of rainfall decreases implying more assurance in the occurrence of the corresponding rainfall. As the 75% and 90% dependability are of great importance in the field of hydrology the same were estimated and found to be 1194 mm and 1023 mm (**Figure 6**).

Table 1. Correlation between Rainfall & Water Availability

YEAR	Rainfall (MM)	Availability of Water (Tha. T.M.C.)
2004&05	1675	4.443
2005&06	1815	20.81
2006&07	1440	19.663
2007&08	1495	14.6773
2008&09	1545	10.7093
2009&10	1249	6.4709
2010&11	2025	20.81
2011&12	1290	14.568
2012&13	1500	16.4664
2013&14	1610	20.81

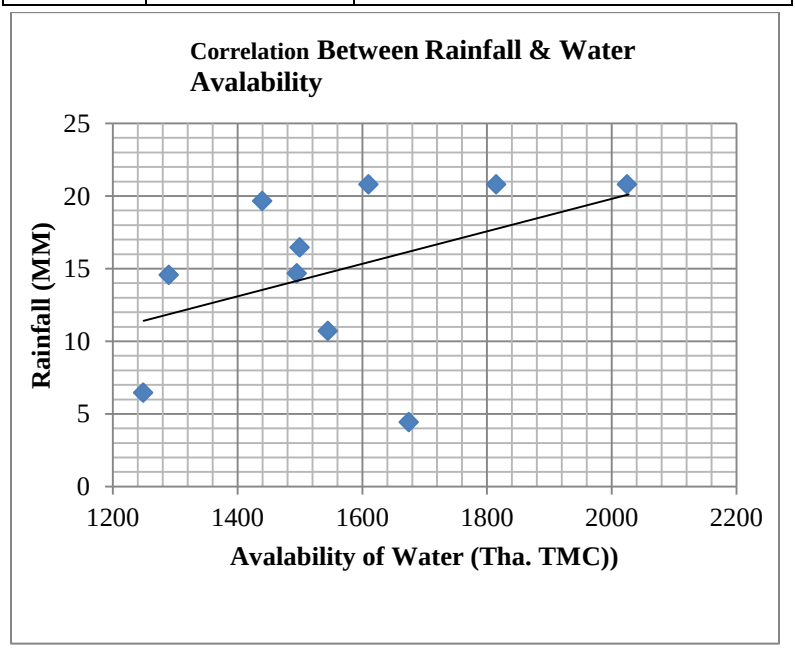


Figure 6. Correlation between Rainfall & Water Avalability

There is a strong correlation between the water capacity of tanks and the quantity of rainfall in the Bodalkasa tank, as evidenced by the positive and high correlation between the medium tank capacity and rainfall (r = 0.728). There is a moderate relationship between the water capacity of tanks and the amount of rainfall in the Chorkhamara tank, as indicated by the positive and moderate correlation between the two variables (r = 0.43).

Hydrology:

The groundwater level's temporal change reveals features such as its ability for recharging through precipitation and its drain from various pressures, including industrial, agricultural, and residential use. Determining the depth to groundwater is one of the most often used metrics in groundwater research. Such information is required to determine the depth to water level before and after the monsoon, the direction of groundwater flow, the variations in water level over time, and the consequences of pumping. The current study examines groundwater fluctuation using NEERI (2016) groundwater level data (Pathare, 2018; Rajasekhar, et al, 2018). It was observed that the pre-monsoon and postmonsoon water level (bgl) varied from 3.28 m to 22.06 m and 1.47 m to 10.71 m respectively. The groundwater level indicates that the wells are tapping the top unconfined aquifer. The majority of the sources are having a shallow water table (<10 m below ground level). The water level measured below ground level (Rajasekhar, et al, 2020). has been converted to water level (above mean sea level) by subtracting the water level (bgl) from the RL of the source. The water level (AMSL) in the pre and post-monsoon indicates that the groundwater flow direction is from northeast to southwest (**Figure 7**).

Agriculture:

The main crop is paddy in the region; therefore other crops are produced in very much less amount in the taluka. Kharif crops completely dependent on monsoon rainfall; though the importance of irrigation could not be neglected. Gram and Tur are the crops that need not irrigation; it produced with the help of soil moisture. 73.37% area irrigated to the total cropped area in the taluka out of which 70% irrigated area under rice. The difference in the crop productivity of Tirora taluka among all five revenue divisions. Rice productivity of Tirora taluka is 1554 kg. per hector; whereas Thanegaon division standing on top as per hector productivity of Rice. Rice productivity in the irrigated area is quite high with 1605 kg. per hector production. Other crops also resulting in high crop productivity in the irrigated area rather than a non irrigated area. In the Vadegaon revenue division having the highest 1825 kg. per hector rice productivity in the taluka. Rice is the dominant crop in the Tirora taluka; therefore cropping pattern of the taluka results from a single crop in all five revenue divisions. In Tirora taluka all five revenue divisions having above 90% area under Rice crop. The study area is small in terms of land; therefore no variation in the physiography, soils, climatic conditions and many

more results single crop pattern in the Taluka. As per the study of total crop productivity and irrigated area productivity; crop productivity in the irrigated area is high then the total cropped area. The main ornament of the Tirora taluka is 152 tanks. In these tanks number of fishermen involved in fishery occupation as a secondary activity. In the Tirora taluka Dhiwar community involved in this occupation; a group of people constitutes a co-operative society to get ownership of the tank. Dhiwar community people involved in this occupation after the primary activity (agriculture). The fishery is the most important allied activity undertaken in the taluka. This enterprise carries special importance as Tirora is known as taluka of lakes and ponds. Fisheries is being practiced in the medium and small irrigation tanks as well as Malgujari tanks. Greater importance is given on production cum employment-oriented activities. All the tanks and ponds in the taluka will be brought under fish production. RKVY Scheme like deepening of Malgujari tanks below sea level is proposed for round the year fish rearing. The establishment of a fish seed rearing pond is also proposed in the taluka. Another marginal activity that depended on the Tanks in the taluka is the 'Singada Occupation'. This is the seasonable additional occupation the Taluka to support the financial requirement of the poor people. Out of 152 tanks 16 tanks are in the occupation of Singada.

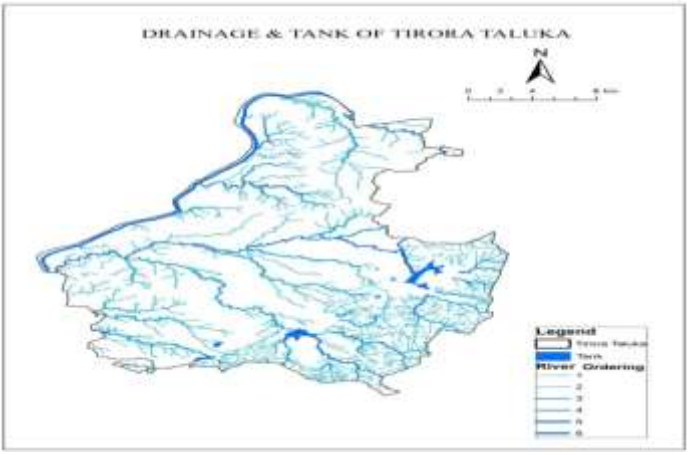


Figure 7. Drainage & Tank

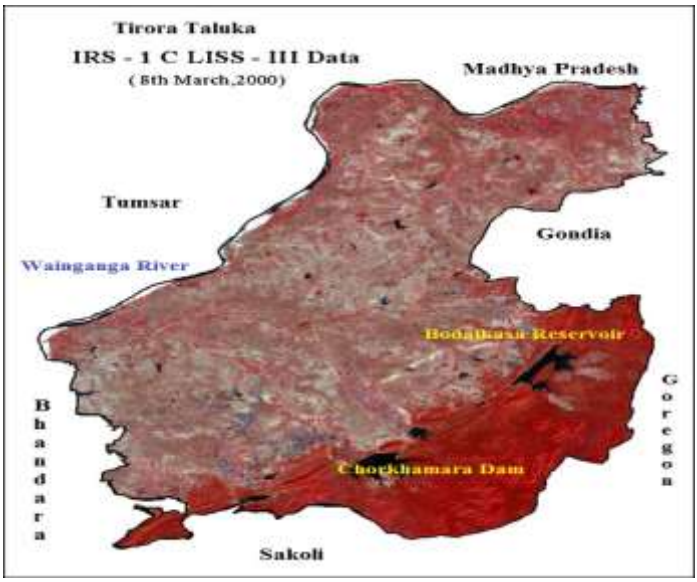


Figure 8. IRS–ID LISS-III Data.

Prioritization of land resource management

The village-wise calorie availability and requirement were analyzed and mapped in GIS for the selected years (Kumar, 2011). Based on the gap analysis, the surplus and deficit zones have been identified to prioritize the critical areas (a group of villages) in the availability of calories for human consumption. Later, the human carrying capacity units were integrated with biophysical resource units through geospatial modeling in GIS to identify the distinct priority areas and analyze their constraints and potentials. The input layers were assigned weights (scale 1-10) and integrated GIS to delineate distinct priority areas based on their potentials and limitations. In the integrated map, higher values higher whereas lower values as lower priority areas for land resource management. Based on the potentials and limitations of delineated priority areas, an action plan has been formulated to enhance the overall unit productivity of land resources in the tehsil (Zolekar, Bhagat, 2015; Dongare, et al 2013).

Conclusions

It is clear that wise use of both surface and subsurface waters can sustain our geomorphology, soil types, geology, slope, relief, landforms, climate and rainfall, hydrology, water availability analysis, water inflow and balance, measurement of water discharge, demographics, and prioritization of land resource management. It is now challenging to predict the monsoon pattern in a methodical manner because to the unpredictable rainfall brought on by global warming. The farming community has had significant difficulties as a result, particularly the small and marginal farmers. Without the necessary professional assistance, farmers have drilled bore wells arbitrarily in order

to maintain their farming practices, which has resulted in debt and suicides. The Tirora tehsil's major irrigation is currently receiving a lot of attention.

References:

1. **Ahmad, N, Pandey P., 2018.** Assessment and monitoring of land degradation using geospatial technology in Bathinda district, Punjab, India. Solid Earth 9(1):75–90. https://doi.org/10.5194/se-9-75-2018
2. **Ali, K., Bajracharya, R. M., Sitaula, B. K., Raut, N., Koirala, H. L., 2017**. Morphometric analysis of Gilgit river basin in mountainous region of Gilgit-Baltistan Province, Northern Pakistan. *Journal Geoscience Environment Protect* 5:70–88
3. **Bhagat, Ravindra; Bisen Devendra 2015.** Flood Study of Wainganga River in Maharashtra, Using GIS & Remote Sensing Techniques, *International Journal of Science and Research*, 782-785.
4. **Bhagat, V. S., 2012.** Use of Remote Sensing techniques for robust digital change detection of land: A review. *Recent Patents on Space Technology*, 2(2), 123-144.
5. **Bhagat, V. S., 2014**. Space-borne passive microwave Remote Sensing of soil moisture: A review. *Recent Progress in Space Technology*, (4) 2, 119-150.
6. **Bisen, D.K.; Kudnar, N.S., 2013a**. A Sustainable Use and Management of Water Resource of the Wainganga River Basin: - A Traditional Management Systems. *figshare. Journal contribution.*
7. **Bisen, D.K.; Kudnar, N.S., 2013b.** Watershed development: a case study of drought prone village darewadi source, *review of research* [2249-894x] d, pp-1-6.
8. **Biswas, S., Sudhakar, S., Desai V.R., 1999**. Prioritization of subwatersheds based on morphometric analysis of drainage basin-a remote sensing and GIS approach. *Journal Indian Society. Remote Sens*ing 27:155–156.
9. **Chattaraj S, Srivastava R, Barthwal AK, Giri JD, Mohekar DS, Reddy GPO, Daripa A, Chatterji S, Singh, S. K., 2017.** Semi-automated object-based landform classification modelling in a part of the Deccan Plateau of Central India. Int J Remote Sens 38(17):4855–4867. https://doi.org/10.1080/01431161.2017.1333652
10. **Dongare, V.T., Reddy, G.P.O., Maji, A.K. et al. 2013.** Characterization of Landforms and Soils in Complex Geological Formations-A Remote Sensing and GIS Approach. *J Indian Soc Remote Sens* 41, 91–104. https://doi.org/10.1007/s12524-011-0195-y
11. **Engelhardt, B. M., Weisberg, P. J. and Chambers, J. C., 2012.** Influences of watershed geomorphology on extent and composition of riparian vegetation. *Journal of Vegetation Science*, 23(1), 127-139.
12. **Forzieri, G., Gardenti, M., Caparrini, F., Hashim, M., 2008.** A methodology for the pre-selection of suitable sites for surface and underground small dams in arid

areas: a case study in the region of Kidal, Mali. *Physical Chemical Earth Parts* A/B/C 33:74–85

13. **Gaikwad, R. D. and Bhagat, V. S., 2017.** Multi-criteria watershed prioritization of Kas Basin in Maharashtra (India): AHP and influence approaches. *Hydrospatial Analysis*, 1(1), 41-61.
14. **Gaikwad Ravindra and Bhagat Vijay, 2018.** Multi-criteria Prioritization for Sub-watersheds in Medium River Basin using AHP and Influence Approaches *Hydrospatial Analysis- Gatha Cogniti* Pp-61- 82.
15. **Howard, A., 1990.** Role of hypsometry and planform in basin hydrologic response. *Hydrological Process* 4:373–385
16. **Horton, R.E. ,1932.** Drainage basin characteristics, *Trans. Amer. Geophysics. U. Vol*. 14. pp. 350-361.
17. **Javed, A, Khanday, M.Y, Ahmed, R., 2009.** Prioritization of sub-watersheds based on morphometric and land use analysis using remote sensing and GIS techniques. *J Indian Soc Remote Sens* 37(2):261. https://doi.org/10.1007/s12524-009-0016-8
18. **Kadam, A.K., Umrikar, B.N. & Sankhua, R.N., 2020.** Assessment of recharge potential zones for groundwater development and management using geospatial and MCDA technologies in semiarid region of Western India. SN Appl. Sci. 2, 312. https://doi.org/10.1007/s42452-020-2079-7
19. **Kale Vishwas S., 1990.** Morphological and hydrological characteristics of some allochthonous river channels, Western Deccan Trap Upland region, India. *Geomorphology* Volume 3, Issue 1, Pages 31-43.
20. **Kale Vishwas S., 2002.** Fluvial geomorphology of Indian Rivers-an Overview Progress. *Physical Geography* 26(3):400-433.
21. **Khan, M.A, Gupta, V.P, Moharana, P.C., 2001.** Watershed prioritization using remote sensing and geographical information system: a case study from Guhiya, India. *J Arid Environ* 49(3):465–475 https://doi.org/10.1006/jare.2001.0797
22. **Kudnar, NS 2020a.** GIS-based assessment of morphological and hydrological parameters of Wainganga river basin, Central India. Model. Earth Syst. Environ. 6, 1933–1950. https://doi.org/10.1007/s40808-02000804-y
23. **Kudnar, NS 2020b.** GIS-Based Investigation of Topography, Watershed, and Hydrological Parameters of Wainganga River Basin, Central India, Sustainable Development Practices Using Geoinformatics, Scrivener Publishing LLC, pp 301-318. https://doi.org/10.1002/9781119687160.ch19
24. **Kudnar, NS, Rajasekhar, M 2020.** A study of the morphometric analysis and cycle of erosion in Waingangā Basin, India. Model. Earth Syst. Environ. 6, 311–327. https://doi.org/10.1007/s40808-019-00680-1

25. **Kudnar, NS, Diwate, P, Mishra VN. et al 2022.** Spatio-temporal variability and trend analysis of rainfall in Wainganga river basin, Central India, and forecasting using state-space models. Theor Appl Climatol 150,469-488. https://doi.org/10.1007/s00704-022-04168-4
26. **Kudnar, NS 2022.** Geospatial modeling in the assessment of environmental resources for sustainable water resource management in a semiarid region: A GIS approach, Editor(s): Mohammad Zakwan, Abdul Wahid, Majid Niazkar, Uday Chatterjee, Current Directions in Water Scarcity Research, Elsevier, Volume 7, Pp 133-151, https://doi.org/10.1016/B978-0-323-91910-4.00009-1
27. **Kudnar, N., Rajashekhar, M. 2023.** Using Geo-Spatial Technologies for Land and Water Resource Development Planning: A Case Study of Tirora Tehsil, India. In: Balaji, E., Veeraswamy, G., Mannala, P., Madhav, S. (eds) Emerging Technologies for Water Supply, Conservation and Management. Springer Water. Springer, Cham. https://doi.org/10.1007/978-3-031-35279-9_15
28. **Kudnar, N.S., Mishra, V.N., Rajashekhar, M. 2023.** Hydro-Chemical Characterization and Geospatial Analysis of Groundwater for Drinking and Agriculture Usage in Bagh River Basin, Central India. In: Rai, P.K. (eds) River Conservation and Water Resource Management. Advances in Geographical and Environmental Sciences. Springer, Singapore. https://doi.org/10.1007/978-981-99-2605-3_6
29. **Kumar A, Jayappa K, Deepika B., 2011.** Prioritization of sub-basins based on geomorphology and morphometricanalysis using remote sensing and geographic informationsystem (GIS) techniques. *Geocarto Int.* 26:569–592.
30. **Kumar, A., 1999.** Sustainable utilization of water resources in watershed perspective Acase study in Alaunja watershed, Hazaribagh. Bihar J *Indian Society Remote Sensing* 27(1):13-22
31. **Laurent, R, Anker, W, Graillot D., 1998.** Spatial modeling with geographic information system for determination of water resources vulnerability application to an area in Massif Central (France). J Am Water Resour Assoc 34(1):123–134. https://doi.org/10.1111/j.1752-1688.1998.tb05965.x
32. **Mark, D.M., 1983.** Relation between field-surveyed channel network and map-based geomorphometric measures, Inez Kentucky. *Ann Association Am Geography* 73(3):358–372
33. **Pathare, J.A., 2018.** Morphometric analysis and runoff studies of Darna Lake catchment. Ph.D. thesis, *Tilak Maharashtra Vidyapeeth*, Pune, pp 22–124.
34. **Pathare, J.A., Pathare, A.R. 2020**. Prioritization of micro-watershed based on morphometric analysis and runoff studies in upper Darna basin, Maharashtra, India. *Model. Earth Syst. Environ.* https://doi.org/10.1007/s40808-020-00745-6

35. **Rajasekhar, M., SudarsanaRaju M., SiddiRaju R., Ramachandra M., Pradeep Kumar, 2018.** Data on comparative studies of lineaments extraction from ASTER DEM, SRTM, and Cartosat for Jilledubanderu River basin, Anantapur district, A.P, India by using remote sensing and GIS, Science Direction, 1676-1682. https://doi.org/10.1016/j.dib.2018.09.023
36. **Rajasekhar, M., Gadhiraju, S.R., Kadam, A. et al. 2020.** Identification of groundwater recharge-based potential rainwater harvesting sites for sustainable development of a semiarid region of southern India using geospatial, AHP, and SCS-CN approach. Arab J Geosci, pp 13-24. https://doi.org/10.1007/s12517-019-4996-6
37. **Ratnam, K., Srivastava, Y., Rao, V., Amminedu, E., Murthy, K., 2005.** Check dam positioning by prioritization of micro-watersheds using SYI model and morphometric analysis remote sensing and GIS perspective. *J Indian Soc Remote Sensing* 33:25–38 DOI: https://doi.org/10.1007/BF02989988
38. **Reddy G.P.O., 2018.** Geospatial Technologies in Land Resources Mapping, Monitoring, and Management: An Overview. In: Reddy G., Singh S. (eds) Geospatial Technologies in Land Resources Mapping, Monitoring and Management. Geotechnologies and the Environment, vol 21. Springer, Cham. https://doi.org/10.1007/978-3-319-78711-4_1
39. **Reshma Parveen, Uday Kumar, Vivek Kumar Singh**, **2012.** "Geomorphometric Characterization of Upper South Koel Basin, Jharkhand: A Remote Sensing & GIS Approach", *Journal of Water Resource and Protection.*
40. **Shailaja, G., Kadam, A.K., Gupta, G. et al.**, **2019.** Integrated geophysical, geospatial and multiple-criteria decision analysis techniques for delineation of groundwater potential zones in a semi-arid hard-rock aquifer in Maharashtra, India. Hydrogeol J 27, 639–654. https://doi.org/10.1007/s10040-018-1883-2
41. **Siddi Raju R, Sudarsana Raju G, Rajsekhar, M., 2018**. Estimation of Rainfall-Runoff using SCS-CN Method with RS and GIS Techniques for Mandavi Basin in YSR Kadapa District of Andhra Pradesh, India, Hydrospatial Analysis 2 (1), 1-15p. https://doi.org/10.21523/gcj3.18020101

Geographical Analysis of Land Use Dynamics in the Ghod River Basin

Hanumant D. Shinde
Head, Department of Geography, Shri Padmamani Jain College, Pabal, Dist. Pune 412403 Maharashtra, India
Email: shindehanumant82@gmail.com

Article DOI Link: https://zenodo.org/records/10559089
DOI: 10.5281/zenodo.10559089

Abstract:-

This research covers 103 villages in the Shrigonda, Karjat, and Shirur talukas and uses sophisticated techniques to gather and analyse detailed land use data. The emphasis is on classifying land use using a combination of supervised and unsupervised techniques, and comparing variations over time using change detection techniques. In order to shed light on the relationship between changes in land use, such as farm expansions, and environmental factors, such as weather changes, the analysis attempts to identify significant changes and trends. The study area is subdivided into Shrigonda, Karjat, and Shirur talukas, comprising 52, 24, and 27 villages, respectively. In Shrigonda taluka, out of the total geographical area of 65,464 hectares, 4.31% is covered by forest, 5.45% is fallow land, and 13.99% is uncultivable. Agricultural activity covers 76.25% of the area. In Karjat taluka, which spans 34,907 hectares, 4.21% is forested, 4.99% is fallow, and 21.54% is deemed unsuitable for agriculture.

Keyword: - Ghod irrigation project, Net Sown Area, Area unsuitable for agriculture, Fallow land, Forest area

Introduction:

The Ghod River Basin is an important area in pune and Ahmednager district that supports different communities, farming, and the environment. As the ghod irrigation project we use land and its impact on the environment becomes even more important. This study wants to understand how the land is being used in the Ghod River Basin. It will use special skills to find information about how people are using the land and how this is affecting the environment. The Ghod River Basin, just like many other places in the world, is dealing with problems caused by cities growing bigger, farmers changing how they do things, and more and more people needing things. The effects of these changes in how we use land go beyond just one area. They affect how water flows, the variety of plant and animal life, how much carbon is stored, and how well the region can handle environmental pressures. This study wants to understand how the land is changing over time in the basin by using geospatial methods. Researcher will present a detailed report on how land is being used in the Ghod River Basin. This evaluation will include past changes, reasons behind them, and possible outcomes for both nature and people living in communities. This study's findings will improve how we understand the

complex connection between how land is used and the environment. It will also be useful for people who make decisions and plans about how to use land in a sustainable way. References provided in the reference list should be need cite in the actual locations in overall manuscript.

The study area

The study area is located between Ghod dam is located in southern drought prone zone of pune and Ahmednagar district this dam construct on Ghod river it is tributary of Bhima River. The height of this area is 600 mt the latitude extend 18° 40′ 41″ to 18° 67′ 80″north and longitude 74° 29′ 33″ to 74° 49′ 24″East hight of dam is 34.74 mt. The region's height goes from 494 to 634 meters, and it is a part of the Deccan Plateau. The study area includes Shrigonda and Karjat talukas. Jamkhed is to the east, Parner is to the north, Daund is to the south, and Khed is to the east of Shirur taluka. For this research, certain areas in the Pune district have been chosen. These areas include 65464 hectares in Shrigonda taluka, 34907 hectares in Karjat taluka, and 49089 hectares in Shirur taluka under the Ghod right canal.

Objective:

1. To investigate the last 20 years' worth of land use trends in the Ghod River Basin.
2. To determine and examine the main causes and variables affecting changes in land use in the Ghod River Basin.
3. To look into how changing land use may affect the environment, particularly how it affects local weather patterns, water availability, and ecosystem services.
4. To investigate the relationship between the Ghod River Basin's changing land use and the area's larger climate change context.

Data Collection and Methodology:-

Secondary data is utilized in the analysis, focusing on a spatial examination at the tehsil level for the year 2011. The data is sourced from summaries of documents published by the Census of India for Ahmednagar and Pune districts. The collected

information undergoes analysis through the use of graphs and tables to derive meaningful insights.

Result Discussion

The agricultural area in Karjat taluka of the study area is 26421 hectares which is 69.26% of the total geographical area. The total geographical area of 27 villages in Shirur is 44033 hectares out of which 585 hectares are covered by forest. It is 1.34% of the geographical area. Whereas the fallow area is 2157 hectares which is 4.95% of the geographical area uncultivable area is 3287 hectares which is 8.64% of the total geographical area and total agricultural area is 37703 hectares which is 85.08% of the total geographical area.

Forest area

The average forest area in the study area is 3.17%, wasteland 3.96%, uncultivable area 13.43% and agricultural area 79.44%. That is, the forest area is less in the study area and between Shrigonda Karjat and Shirur taluka, the least forest area is in Shirur taluka and the maximum forest area is in Shrigonda taluka. Village wise forest area in the study area is highest in Bhingan Khurd 23.41 %, Mengalwadi 20.71 %, Dhalwadi 19.28 %, Vadgaon Shindodi 17.33 %, Pimpri Kolandar 16.24 %, Bardgaon 15.91 %, Kansevadi 14.87 %, Sonalwadi 13.51%, Rakshaswadi Khurd 13.35%, Talwadi 12.44%, Sardwadi 10.82%, Bori 10.47%, Taklewadi 10.32%. Whereas 50% of the villages in the study area have no forest area this is an alarm bell for the region. Farmers are reducing the forest area due to horticultural agriculture. The trees on Banda are decreasing. Fruit trees are cultivated to some extent. But they are less than logging. And since the lifespan of this orchard is short, the damage to the environment cannot be reduced.

Fallow land

Rajapur 37.97%, Yesewadi 27.11%, Dudhodi 26.60%, Shirajgaon Bodkha 25.06%, Berdi 24.14%, Chormalewadi 20.11% have the highest fallow area in the study area. This ratio is high as the area at Rajapur is submerged in Ghod Dam. 48 % village have is no fallow area in the village.

Area unsuitable for agriculture

Most uncultivable area for agriculture is in Rakshaswadi Budruk 53.48% Hingangaon 51.13%, Shindodi 45.31%, Chormalewadi 40.98%, Khed 39.67%, Ganeshwadi 39.59%, Mengalwadi 36.38%, Bhingan Dhumal 35. .92%, Deulwadi 34.85%, Shifalkarwadi 32.59%, Srigonda 32.08%, Balewadi 31.57%, Sonalwadi 30.98%, Raigavan 30.81%, Chandgaon 30.65% and Rakshaswadi Khurd 30.14% out of which Srigonda is an urban place and the area unsuitable for agriculture the uncultivated area in the village is less than 2%.

Table no 1.1

Village Name	Forest area	Fallow land	Area unsuitable for agriculture	Net Sown Area
Shrigonda	6.67	7.61	32.08	53.64
Ghodegaon	0	2.46	0.51	97.03
Bhingan Khalsa	0	1.61	35.92	62.47
Bhingan Dumala	23.41	4.01	8.7	63.88
Velu	1.93	19.59	16.24	62.24
Chorachiwadi	3.78	0	40.98	55.24
Hiradgaon	6.87	0.28	28.03	64.82
Chandgaon	9.04	0.41	30.65	59.9
Takli Kadevalit	10.32	0	26.73	62.94
Adhorwadi	0	4.48	28.39	67.13
Anandwadi	0	1.01	2.62	96.37
Chikhalthanwadi	0	4.05	2.86	93.1
Kansewadi	14.87	0	20.59	64.53
Mudhekarwadi	0	0.26	0	99.74
Ajnuj	0	1.14	8.07	90.79
Arvi	4.01	0	21.66	74.33
Angare	2.6	0	8.27	89.13
Kouthe	0.81	5.03	15.49	78.67
Shipalkarwadi	5.49	3.77	32.59	58.15
Pedgaon	4.06	0.18	13.65	82.11
Shedgaon	0	2.38	0	97.62
vangdari	0	0.53	2.11	97.37
Masalwadi	0	7.59	21.1	71.31
Choramlewadi	7.47	20.11	12.64	59.77
Dhokrai	0	1.18	12.09	86.73
Domalewadi	0	0.88	10.32	88.79
Mhatar Pimpri	4.8	4.62	4.26	86.32
Limpangaon	0.45	4.88	6.07	88.6
Janglewadi	4.01	12.27	23.69	60.02
Gar	0.69	1.89	5.15	92.28
Kashti	1.45	1.45	1.71	95.38
Sagvi Dumala	3.7	2.64	10.39	83.27
Nimgaon Khalu	4.12	2.23	9.7	83.95
Chimbhale	3.99	0.65	3.14	92.22
Shirasgaon Bhodkha	0.84	25.06	2.19	71.91
Baburdi	3.11	4.53	6.88	85.47
Hangewadi	0	0.4	10.97	88.63

Bori	10.47	5.49	12.47	71.57
Pisore	0	7.31	1.78	90.91
Policwadi	6.9	11.38	12.99	68.74
Yelpane	3.93	14.76	27.97	53.34
Mhdewadgaon	0	0.27	0.98	98.76
Pimpri Kolandar	16.24	0	14.96	68.8
Ukkadgaon	0	1.14	1.14	97.72
Mengalwadi	20.71	14.55	36.38	28.36
Rayagavhan	0.64	6.55	30.81	62
Mhase	8.16	8.28	14.37	69.2
Wadgoan Shidodi	17.33	19.53	12.33	50.81
Matha	0	0	8.36	91.64
Rajapur	2.1	37.97	10.63	49.3
Danewadi	7.76	6.72	12.69	72.84
Hingani Dumala	1.45	0	13.32	85.23

Graph no 1.1

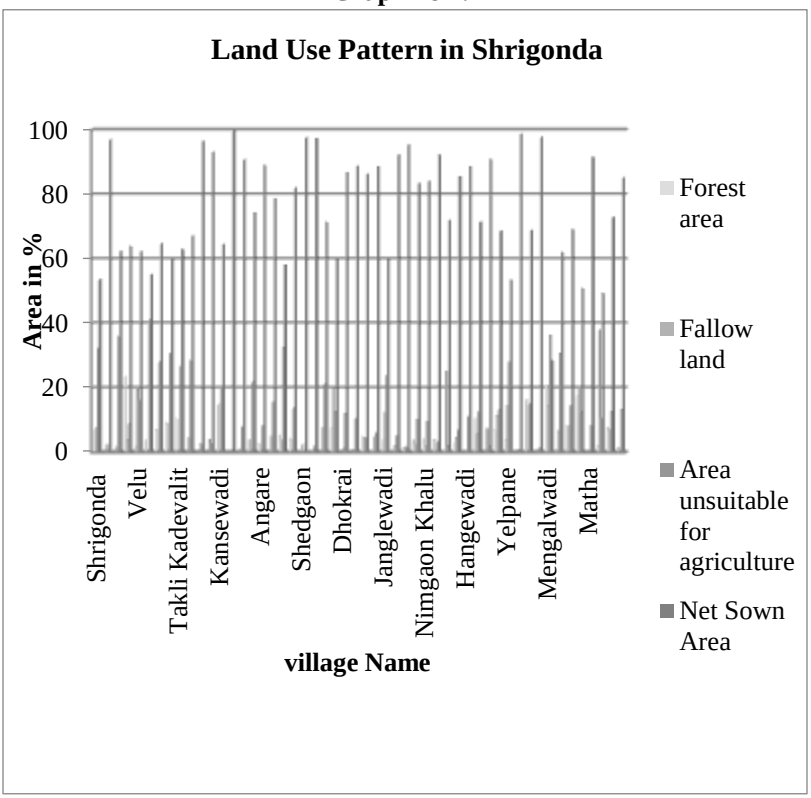
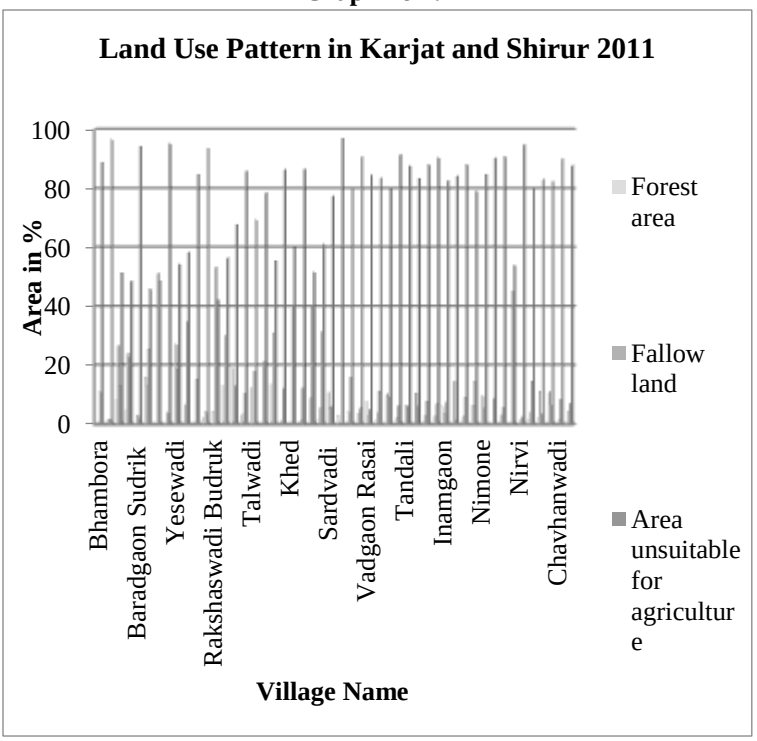


Table no 1.2

Village Name	Forest area	Fallow land	Area unsuitable for agriculture	Net Sown Area
Bhambora	0	0	11.12	88.88
Taju	0	1.64	1.8	96.56
Dhudhodi	8.71	26.6	13.22	51.46
Berdi	5.13	24.14	22.24	48.48
Baradgaon Sudrik	0.57	3.08	2.11	94.24
Baradgaon Dagdi	15.92	12.8	25.45	45.83
Hingangaon	0	0	51.13	48.87
Jalalpur	0.4	0.49	3.93	95.18
Yesewadi	0	27.11	18.68	54.21
Deulwadi	0	6.83	34.85	58.31
Siddhatek	0	0	15.3	84.7
Kuldharan	2.23	0	4.15	93.62
Rakshaswadi Budruk	4.37	0	53.48	42.15
Rakhaswadi Khurdh	13.35	0	30.14	56.5
Dhalwadi	19.28	0	13.01	67.71
Pimpalwadi	3.4	0	10.64	85.96
Talwadi	12.44	0	18.26	69.3
Rashin	0	0	21.35	78.65
Sonalwadi	13.54	0	30.98	55.49
Waysewadi	0	1.29	12.15	86.56
Khed	0	0	39.67	60.33
Karmanwadi	0	1.29	12.15	86.56
Ganeshwadi	0	8.79	39.59	51.62
Balwandi	1.61	5.76	31.57	61.06
Sardvadi	10.82	5.64	6.11	77.43
Tardobachiwadi	3	0	0	97
Golegaon	0	4.26	16.11	79.63
Ambale	0	3.8	5.48	90.72
Vadgaon Rasai	7.9	2.55	4.86	84.68
Sadalgaon	1.15	4.07	11.27	83.51
Mandavgan Farata	0.74	10.2	9.18	79.88
Faradwadi	0	2.02	6.47	91.51
Tandali	0	6.51	5.82	87.67
Ganegaon Dumala	0	10.47	6.1	83.42
Babulsar Budruk	1.03	3.26	7.78	87.93
Karegaon	0	2.7	6.86	90.45
Inamgaon	6.34	3.79	7.27	82.6
Pimpalsuti	0	14.44	1.33	84.22
Shirasgaon Kata	0	2.82	9.19	87.99

Dhumalwadi	0	6.45	14.41	79.13
Nimone	0	9.71	5.45	84.84
Motewadi	0	0.71	8.79	90.5
Gunat	0	3.37	5.86	90.77
Shindodi	0	0.78	45.31	53.91
Nirvi	0.59	1.73	2.72	94.95
Chichani	1.56	3.85	14.53	80.06
Kolgoan Dolas	2.14	11.21	3.47	83.18
Kuruli	0	10.99	6.56	82.44
Chavhanwadi	0	1.33	8.6	90.08
Karde	0.87	4.44	6.9	87.78

Graph no 1.2



Net Sown Area:

Most of the agricultural areas are Mundekarwadi, Madhewadgaon, Ukkadgaon, Shedgaon, Ghodegaon, Tardobachi wadi, Taju, Anandwadi, Kashti etc., more than 95% of the geographical area is agricultural. And Mengalwadi village has less than 50% area used for agriculture while Shirur has the lowest net sown area of 25.69%.

Conclusion:

The cultivation pattern of a region reflects the influence of various physical and

socio-economic factors. The oracle country has about 85 % of the geographical area, which shows that it is hardly possible to significantly increase the land resource. Therefore, the intensity of agriculture must be increased by introducing technological changes. Increase the celerity of actual conclusions obtained from overall research topic. Given conclusion does not summarize the purpose of research paper writing as well as not clarifying the outcomes of the work. Specify the conclusion.

Reference:

1. Ali Mohammad 1978 studies in agriculture geography Rajesh publication new Delhi
2. Census of India 2011District census hand book Ahmednager and pune
3. Maharashtra State Forest Sector Report 2019 p. 155
4. N.B.Patil and B.S. Jadhav Agricultural Geography p. 29
5. Shivram Thakur and Dr. R. B. Patil Publications, Geography of Agriculture and Disaster Management, Institute of Distance and Open Studies, University of Mumbai p.24
6. Saptarshi P.G. (1987): 'Social forestry and Dairy Forming" Mahar~shtra Bhugolshastra sanshodhan Patrika" Maharashtra Bhugolshastra Panshad, Pune Vol 1 No.1 Pp. 27-37
7. Saptarshi P.G. (1992): "A Geographical Assessment of Forest Resources in Karjat and Mawal", a paper presented at the Third Annual Conference of NAGI, Pune, Feb. 1992
8. Singh, Abha Laxshmi (1992): "Impact of Different sources of Irrigation on cropping pattern, Yield and Farm Practices", Geographical Review of India, 'The Geographical Society of India, Calcutta, Vol: 54, No: 1, PP: 19-30.
9. Sonawane A. K. (2013) “Cost Effective Use Water Resource For agriculture in Shirur Tahsil of Pune District (Maharashtra)” unpublished Ph.d Submitted to Pune University Pune,
10. Subrahmaniam A. R. and Raju P.A.N. (1986): "Droughts in North Coastal Andra A climatic study" Annals, NAG-7, Vol. VI, No. : 1, June. 1986, Pp: 9- 13.

Agro-Climatic Planning for Sustainable Agricultural Development: A case Study of North Chotanagpur Plateau

Basudeo Prasad
Associate Professor and Head, Post-Graduate Department of Geography, J.J. College, Gaya (Magadh University, Bodhgaya), Bihar, India.
Email: prasadbasudeo05@gmail.com

Article DOI Link: https://zenodo.org/records/10559100
DOI: 10.5281/zenodo.10559100

Abstract:

The Agro-Climatic Planning with regional approach aims at a more scientific utilization of natural resources available in the North Chotanagpur Plateau. This is based on the endowment of natural resources like land, soil, water, climate and new technologies in various agriculture activities. On the basis of these agro-climatic factors and their principal characteristics has been utilized and applied for regionalization. Land, soil, climate and water are vital natural resources for agriculture. Considering all changes in natural cycles and human activities, agro-climatic suitability assessment will act as an important base of sustainable agricultural development plan, in the present era. The present study is essentially a natural resource-based planning in terms of agro-climatic conditions with available resources, physical setup of the region and moisture adequacy regimes. The North Chotanagpur Plateau is a region which has great opportunities of agricultural development through systematic appraisal of its natural resources. It is a well-defined geographical unit and the locational advantage, sub-tropical monsoon climate of this plateau.

Keywords: Landforms, Climatic Conditions, Agro-climatic region, Soil and Moisture adequacy, Sustainable agricultural development

Introduction:

Agro-Climatic Regional Planning (ACRP) is designed for agricultural development of North Chotanagpur Plateau. The introduction describes the importance of Agro-Climatic Region Planning, the earlier developments, present status and its relevance for the future planning in North Chotanagpur Plateau. The discussions on acceleration of growth in production and productivity in irrigated and rainfed areas, crop diversification, food and nutritional security, sustainability of resource, augmentation of the farmers income for agricultural development in the various Agro-Climatic Regions.

Food security to its inhabitants is one of the prime objectives of the present development. Although, the Green Revolution Since 1960 provided the much-needed food security to the vast population of India; India Vision 2021 says that to reduce food insecurity and poverty, India will have to sustain an agricultural growth rate of 5.0-5.5%.

North Chotanagpur Plateau is a potential region but still suffers from low productivity. In so far as demand for food articles is concerned, it depends on the growth of population, income per capita, distribution of income, elasticity of demand for food and other requirements. Among twin forces, an increase in the growth rate of population leads to a direct increase in the rate of growth of demand for food grains albeit at a lower rate.

The interactions of these elements are studied in agro-climatic which deal with the study of crop distribution and production in relation to physiography; soil and climatic factors. The types of land defined in terms of major climate and growing periods, which is economically suitable for a certain range of crops and cultivators.

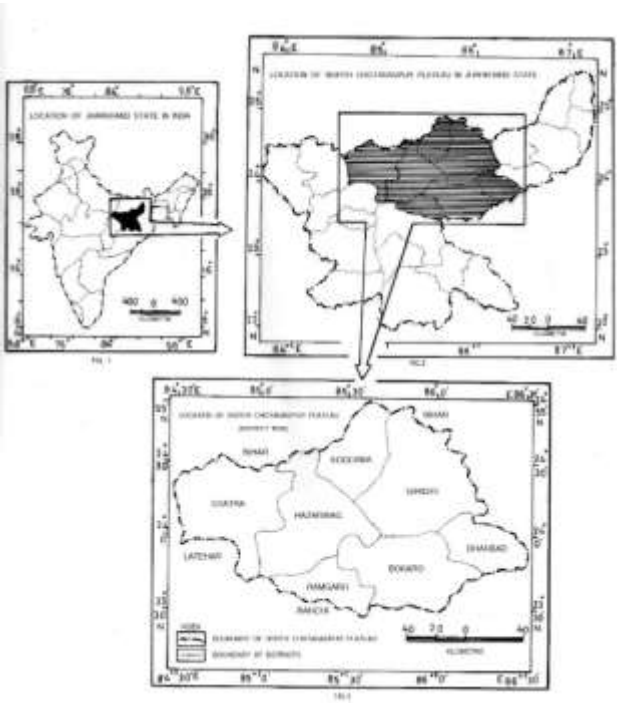
Soil and climate based agro-climatic suitability analysis areas. The Agro-Climatic Regional Planning is essentially resource based planning in terms of techno-agro-climatic conditions. The Government planners, policy makers and others have drawn more emphasis on regionalization of agriculture on the basis of broad natural resources, existing cropping patterns and other related factors to make strategy for development planning. The dimensions of technology and sustainability are integral to resource-based planning. This technology will lead to utilizations of natural resources and more efficient use of land and water resources. Failing to notice the problems of the study region there is an urgent need to make a strategy for sustainable agricultural development.

Objectives:

The main objective of the present study is to study Agro-Climatic parameters with approach of Regionalization on the basis of natural resources including physiography, landuse, soil, climatic elements of North Chotanagpur Plateau. In addition, it has also aims to the study characteristics of Agro-Climatic Region along with different crops grown of areal coverage and production of different crops, proper planning should be done.

Data and Methodology:

The required data of climatic elements like rainfall, temperature have been obtained from the ATMJ (Agricultural Technology Modules for Jharkhand), Birsa Agricultural University, Ranchi for the period of 2015-2019. Secondary data used for preparing meteorological stations collected and different publications from the records of the Birsa Agricultural University, Ranchi, Jharkhand. The base map of the North Chotanagpur Plateau was prepared on 1:50000 scale using survey of India different toposheets for delineation of Agro-Climate Regions each parameter has been separately mapped and by overlapping these maps with minor adjustments Three Agro-Climatic Regions have been identified. At last the Agro-Climatic Regional Planning is presented for the sustainable development of North Chotanagpur Plateau.



Study Area: North Chotanagpur Plateau is lies between 23°30′ to 24°55′ North Latitude and 84°30′ to 86°30′ East Longitude (Fig. 1 to 3). It has a North Chotanagpur. Plateau border Bihar State in North, South Chotanagpur Plateau in the West-South, West Bengal State in the South-East and Santhal Parganas in the East. The North Chotanagpur Plateau forms part of Chotanagpur Plateau areas. North Chotanagpur Plateau have seven districts, namely-Chatra, Hazaribag, Ramgarh, Bokaro, Dhanbad, Giridih and Koderma of Jharkhand State. The total Geographical areas is 22230 sq.km and total population of the same is 11635374 including 1311661 total tribal population as of the 2011 census.

Landforms:

The area under study is Geomorphology defined as comprehensive of all aspects dealing with the surface configuration. Main attention is given to landforms resulting in an account of structure and relief of the area. The North Chotanagpur Plateau presents a best case for such studies where Geomorphology of the area has a role in limiting the Agro-Content of different portions of the Plateau. Geomorphological studies of the area will be helpful in understanding the favours and limitations to agricultural uses of lands as well as scope of agricultural planning in North Chotanagpur Plateau. The chief undulating Pediplain characteristics of landforms are Plateau, residual hills and intermountain valleys. Weathered granite-gneiss serves as the principal aquifer in the

study area (Fig. 4).

Physiographically, the North Chotanagpur Plateau can be divided into four divisions (Fig. 6), viz. the Upper North Chotanagpur Plateau, Lower North Chotanagpur Plateau, Scrap and Damodar Basin. The upper North Chotanagpur Plateau is situated in the Southern part having an average elevation varies from 500ft.-1000ft. and South-East from below 500ft. from the mean sea level (Fig. 5). The upper North Chotanagpur Plateau extends over the upper Hazaribag Plateau, Ramgarh, South Bokaro and South-East Dhanbad District (Fig. 6).

The Lower North Chotanagpur Plateau extends over Koderma, North Hazaribag, Chatra and Giridih districts (Fig. 6). This Plateau region has a general elevation 1000ft. to 2000ft (Fig. 5). The highest point of Parasnath peak elevation is 4490ft. in the North Chotanagpur Plateau (Fig. 5). It is located towards the extreme of the North Chotanagpur Plateau in the Giridih district. The Scarps areas run generally East-West and at South-Western part of Koderma and Chatra districts. There are four prominent mainly Scarps on this Plateau. From North to South the firsts lie between the fringe of the lower Gaya and Koderma-Chouparan. The second lies in between the sub-plateau of the North and the Hazaribag plateau. Third Scarps bound the Damodar Basin and fourth Scarps Chatra and Giridih Districts. Generally, these Scraps areas are at the different Plateaus level and stand as narrow strips of lands (Fig. 6). Their width varies from 1 km to more than 10 km. The Damodar Basin is on such a valley whose continuation in the west is supposed to reach in an East-West direction via the coal fields (Fig. 6).

The North Chotanagpur Plateau is drained by four major rivers are Damodar, Barakar, Konar and Bokaro with a few minor tributaries like Barsoti, Ghaghara, Phutla, Lilajam, Sakari, Khero, Usari, Chikari, Mohne and other smallest rivers (Fig. 7). The Southern main tributaries of Damodar river have developed characteristics of valley inside the edges of the escarpment, sending long arms into parallel ridges has developed the largest number of such valleys. The Barakar river valley is endowed with cultivated fields near Ichak, but the gorges that it has notched in the Northern escarpment of the Plateau has reached at a lower point 9.5 kilometres away from the source. Here the river tumbles over a number of small falls and rapids in a wild setting (National Park). Other rivers from a broad tree-like sub-derdritic and trellis pattern on the North Chotanagpur Plateau.

Soil found in the North Chotanagpur Plateau are broadly classified in five types i.e. red soil, mica content soil, sandy soil, laterite soil and alluvial soil. The natural vegetation of a region provides the best index as its soil and climate condition from the observation of denser forest it can be interested that the climate is hot and wet monsoon type. Therefore, this plateau contains most deciduous and dry deciduous forests (Fig. 8).

Results and Discussion:

In the present study of North Chotanagpur Plateau under Agro-Climatic Region (ACR) based on geological formation, physiography, soils, climate, cropping pattern and development of irrigation for broad agricultural planning and developing future strategies. On the basis of above determinant, the region has been identified in to three Agro-Climatic Regions (Fig. 9) by humid to sub-tropical monsoon.

1. Western part of North Chotanagpur Plateau Agro-Climatic Region.
2. North-Eastern part of North Chotanagpur Plateau Agro-Climatic Region.
3. South-Eastern part of North Chotanagpur Plateau Agro-Climatic Region.

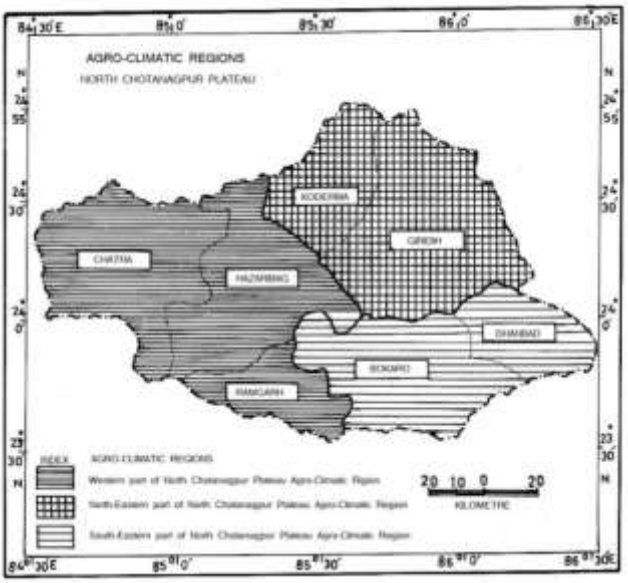


FIG. 9

1. **Western part of North Chotanagpur Plateau Agro-Climatic Region**

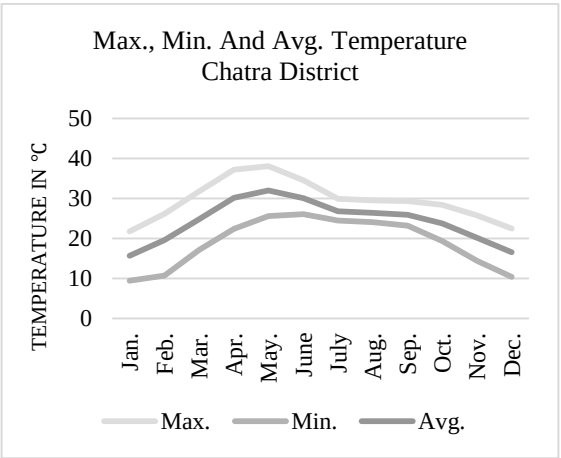
The Western part of North Chotanagpur Plateau comprises of only three districts of Chatra, Hazaribag and Ramgarh. This region is characterized by sub-humid type of climate. Climate also has a great influence on agricultural production. The climate as a physical factor is a great Agro-Climatic determinant of sustainable agricultural development. Agro-Climatic Region is dependent upon favourable temperature and rainfalls. Temperature is the most important factor of climate. The meteorological records temperature and rainfall data available for have direct significance in agriculture developed. It has been possible to obtain maximum, minimum, average temperature and rainfalls of the three districts.The following table shows the monthly temperature and rainfall during the year 2019.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Table 1 : Maximum, Minimum, Average monthly temperature and rainfall of Western part of North Chotanagpur Plateau, 2019

Month	District Wise Temperature (℃) and Rainfall (mm)											
	Chatra District				Hazaribag District				Ramgarh District			
	Temperature			Rainfall	Temperature			Rainfall	Temperature			Rainfall
	Max.	Min.	Avg.		Max.	Min.	Avg.		Max.	Min.	Avg.	
Jan.	21.8	9.4	15.7	18	21.2	8.9	14.8	17	22.7	9.3	15.9	15
Feb.	26.2	10.7	19.6	19	25.1	12.3	18.6	19	26.7	13.0	19.8	13
Mar.	31.8	17.1	24.8	15	30.2	16.5	23.4	18	31.7	17.2	24.6	18
Apr.	37.2	22.4	30.2	11	35.3	20.8	28.2	17	36.7	21.6	29.4	14
May.	38.1	25.6	32.0	28	36.0	23.4	29.7	47	37.3	24.4	30.8	38
June	34.6	26.1	30.1	183	32.6	24.3	28.1	228	33.6	25.2	29.0	186
July	29.9	24.5	26.8	318	28.5	23.2	25.4	328	29.3	23.9	26.1	294
Aug.	29.5	24.1	26.4	268	28.2	22.8	25.0	383	28.9	23.5	25.8	257
Sep.	29.4	23.2	25.9	203	28.0	22.1	24.6	201	28.9	22.8	25.4	187
Oct.	28.4	19.4	23.8	69	27.1	18.7	22.6	77	28.2	19.3	23.6	66
Nov.	25.8	14.4	20.2	10	24.6	13.8	19.0	12	25.8	14.4	20.0	11
Dec.	22.5	10.4	16.6	8	21.7	9.9	15.5	8	22.9	10.2	16.4	9

Source: en.Climate_data.org/jhark.


Max., Min. And Avg. Temperature
Chatra District
TEMPERATURE IN °C
50
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Max.
Min.
Avg.

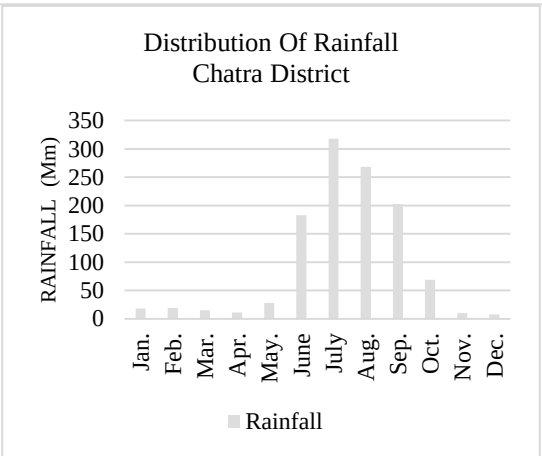
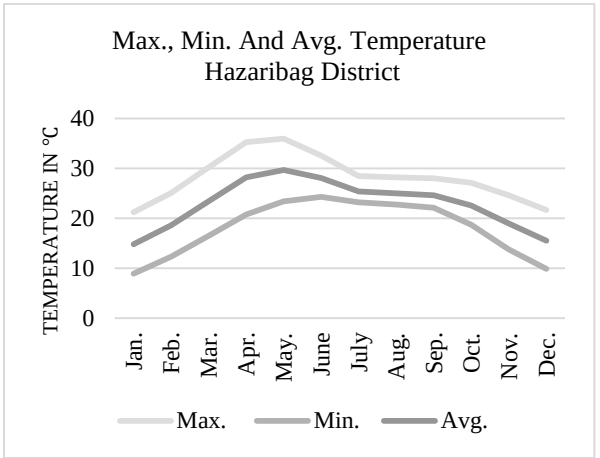

Distribution Of Rainfall
Chatra District
RAINFALL (Mm)
350
300
250
200
150
100
50
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Rainfall

FIG. 10


Max., Min. And Avg. Temperature
Hazaribag District
TEMPERATURE IN °C
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Max.
Min.
Avg.

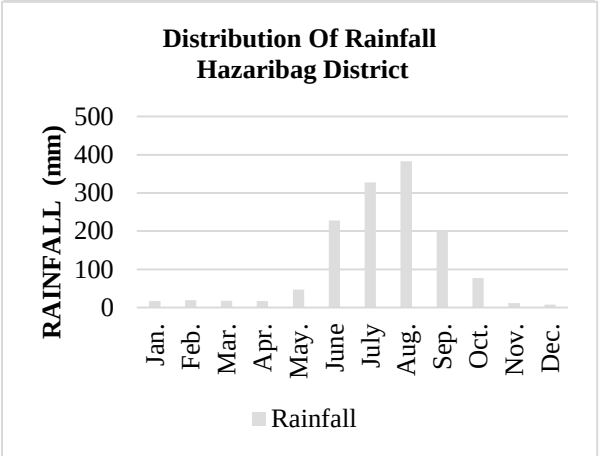

Distribution Of Rainfall
Hazaribag District
RAINFALL (mm)
500
400
300
200
100
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Rainfall

FIG. 11

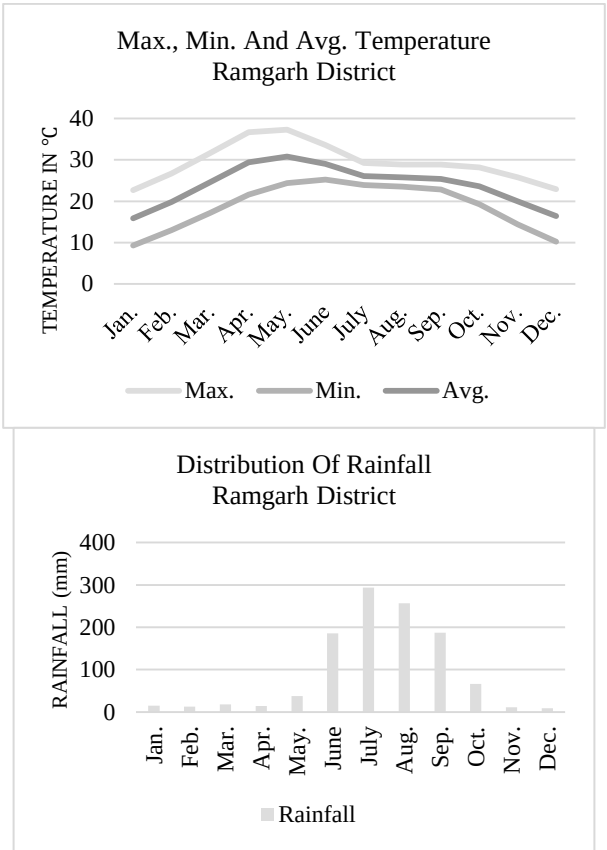


FIG. 12

The above table shows the monthly maximum, minimum and average temperature and rainfall (Fig. 10, 11 & 12) of three districts. The measured annual rainfall amounts to 1150mm (Chatara District), 1355mm (Hazaribag District) and 1114 mm (Ramgharh District) which nearly 90% of the rainfall is concentrated between four months (June to Sept.) and water surplus occurs in rainy season. Usually, the crop cultivation in this region is rainfed and 80% irrigation particularly in Rabi season.

The soil is a very important element on which agricultural use of land. The soil of this area is sandy, red, clay loams and alluvial. The sandy and red soil are generally not good quality for agriculture and clay loams and alluvial soils are good quality for agriculture. The six type of lands viz. tanr lands-I, II and III (uplands) and don lands-I, II and III (Low lands). There are two seasons of raising crops in this plateau region i.e. Kharif and Rabi are known as two main cropping seasons. Usually, Kharif crops (Bhadai crops) like paddy (rice), maize, pulses, small millets and crops are economically grown in higher moisture. Rabi crops are generally grown like wheat, oilseeds (Surguja and

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Mustard), Vegetables and Pulses (Urad and Kulthi).

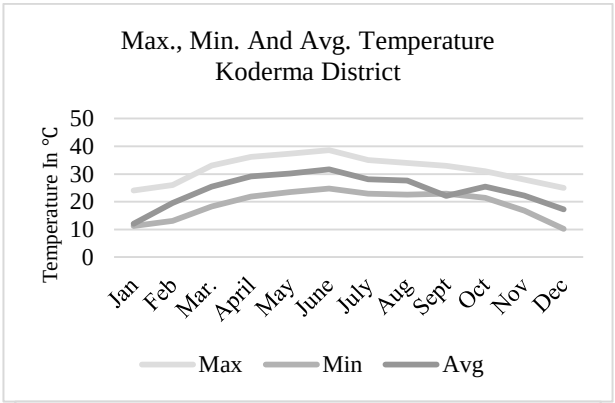
2. North-Eastern part of North Chotanagpur Plateau Agro-Climatic Region

The North-Eastern part of North Chotanagpur plateau comprises two districts of Koderma and Giridih (Fig. 9). The climate of this region is Characterized by semi-humid types. Moisture adequacy index ranges between 65 to 70 percent. This area is characterized by little water surplus with four months (June to Sept.). This climatic region is dependent upon favourable temperature and rainfall. The meteorological records temperature and rainfall data available for agricultural developed. The maximum, minimum, average temperature and rainfall of the two districts. The following table shows the monthly temperature and rainfall during the year 2019.

Table 2 : Maximum, minimum, average monthly temperature and rainfall of North-Eastern part of North Chotanagpur plateau,2019.

Month	**District Wise Temperature (℃) and Rainfall(mm)**							
	Koderma district				**Giridih district**			
	Temperature			Rainfall	Temperature			Rainfall
	Max.	Min.	Avg.		Max.	Min.	Avg.	
Jan.	24.0	11.2	12	4.5	22.5	9.9	15.9	17.7
Feb.	26.0	13.1	19.5	6.0	26.7	13.4	19.9	18
Mar.	33.1	18.3	25.5	8.0	32.2	17.8	25.1	18
April	36.2	21.9	29.1	6.7	36.8	22.2	29.6	22
May	37.3	23.5	30.2	25.1	36.7	24.7	30.5	67
June	38.6	24.8	31.7	165.1	33.9	25.7	29.4	210
July	35.0	22.9	28.1	323.7	30.3	24.7	27.1	312
Aug.	34.0	22.6	27.6	322.9	30.0	24.4	26.7	260
Sept.	33.0	22.9	22.1	214.3	29.8	23.7	26.3	214
Oct.	31.0	21.4	25.4	40.0	28.9	20.3	24.4	79
Nov.	28.0	16.8	22.2	4.0	26.5	15.2	20.7	12
Dec.	25.0	10.2	17.2	4.2	23.2	11.2	17	8
Total=1124.5					**Total=1237.7**			

Source: en.Climatedata.org/jhar


Max., Min. And Avg. Temperature
Koderma District
Temperature In °C
50
40
30
20
10
0
Jan
Feb
Mar.
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Max
Min
Avg

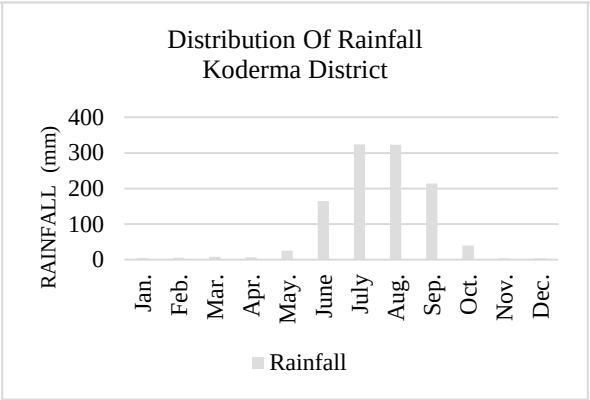
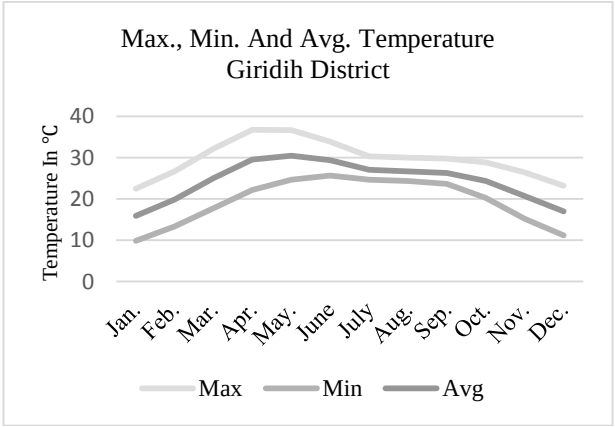

Distribution Of Rainfall
Koderma District
RAINFALL (mm)
400
300
200
100
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Rainfall

FIG.13


Max., Min. And Avg. Temperature
Giridih District
Temperature In °C
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May.
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Max
Min
Avg

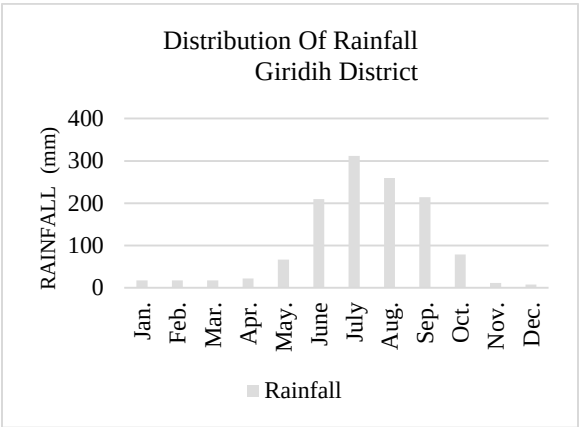


FIG.14

The above table shows the monthly maximum, minimum, average temperature and rainfall of Koderma and Giridih District (Fig. 13 & 14).

The average temperature of the region 25.4℃ while the annual rainfall is 1124.5mm (Koderma district) and 1237.7mm (Giridih district). This amount of rainfall (1124.5mm and 1237.7mm) is concentrated between four months (June to Sep) annual water deficit. This region is mainly drained by the rivers Barakar and their tributaries. This area has alluvial soil in don lands which is very much suitable for agricultural crops. Kharif and Rabi both crops are grown here under rainfed conditions. In upland rainfed areas, instead of rice high value crops like oilseeds and pulses. Crops like groundnut and Maize in Kharif and Wheat in Rabi, under irrigated conditions, should be increased in uplands. Rice and maize are intensively cultivated in Kharif season. The common Rabi crops are Wheat, oilseeds and pulses grown with the combination of other crops. In this region yield of rice and wheat is highest in the entire study area.

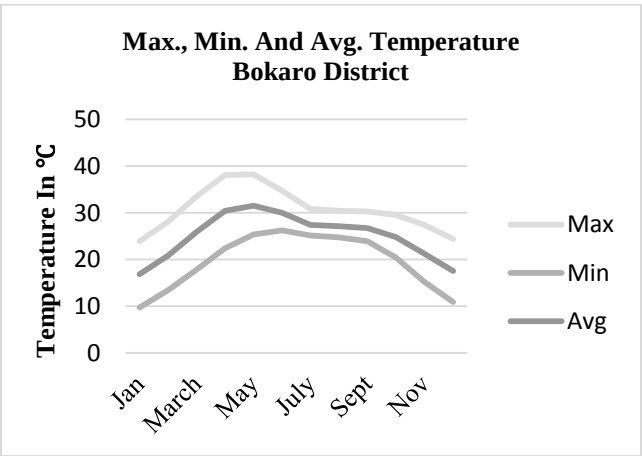
3. South-Eastern Part of North Chotanagpur Plateau Agro-Climatic Region

The South-Eastern part of North Chotanagpur plateau has two districts, viz. Bokaro and Dhanbad (Fig. 9). This region is characterized by sub-humid type of climate having less than 65% moisture. Hot summer, humid rainy and winter seasons are the major features of climate of this region. The average annual temperature of this region is about 26.3℃ and annual rainfall recorded over the region comes to 1230mm.& 1241mm. The following table shows the monthly temperature and rainfall during the year 2019.

Table 3 : Maximum, minimum, average temperature and rainfall of South-Eastern part of North Chotanagpur plateau,2019.

Month	District Wise Temperature(℃) and Rainfall(mm)							
	Bokaro District				Dhanbad District			
	Temperature			Rainfall	Temperature			Rainfall
	Max.	Min.	Avg.		Max.	Min.	Avg.	
Jan.	23.9	9.7	16.8	13	23.8	10.4	16.9	12
Feb.	28.1	13.4	20.8	19	27.9	13.9	20.8	20
March	33.5	17.8	25.9	18	33.2	18.2	25.8	19
April	38.1	22.4	30.4	18	37.7	22.7	30.2	21
May	38.2	25.3	31.5	63	37.4	25.3	31	74
June	34.7	26.2	30	219	34.4	26.1	29.8	224
July	30.8	25.1	27.4	299	30.7	25.1	27.4	298
Aug.	30.4	24.7	27.1	273	30.4	24.8	27.1	263
Sept.	30.3	23.9	26.7	219	30.2	24.0	26.7	219
Oct.	29.5	20.4	24.8	70	29.4	20.7	24.9	74
Nov.	27.4	15.2	21.2	10	27.3	15.8	21.4	9
Dec.	24.4	10.9	17.5	9	24.3	11.8	17.8	8
				Total=1230				Total=1241

Source: en.climate-data.org/jhark



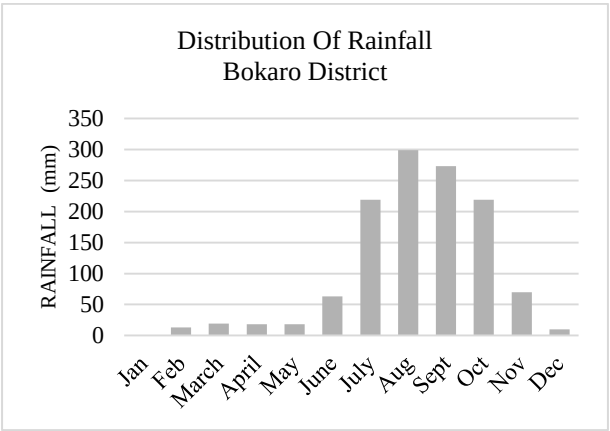
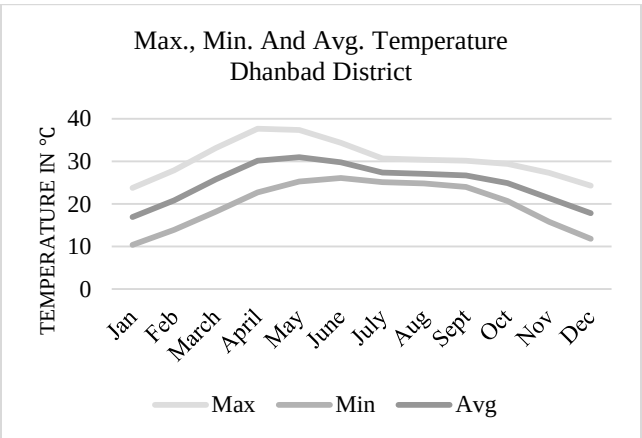

Distribution Of Rainfall
Bokaro District
RAINFALL (mm)
350
300
250
200
150
100
50
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec

FIG. 15


Max., Min. And Avg. Temperature
Dhanbad District
TEMPERATURE IN °C
40
30
20
10
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Max
Min
Avg

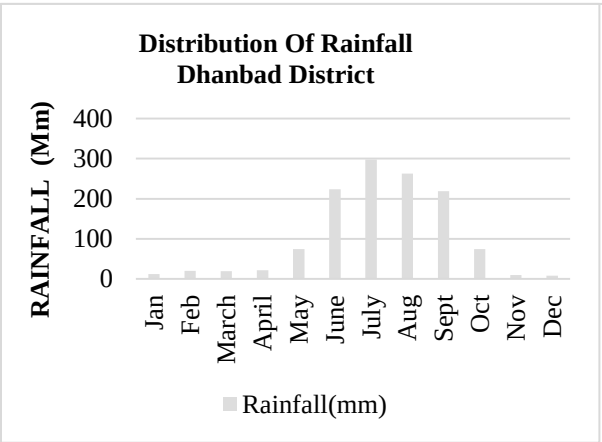

Distribution Of Rainfall
Dhanbad District
RAINFALL (Mm)
400
300
200
100
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Rainfall(mm)

FIG. 16

The above table shows the monthly maximum, minimum, average temperature and rainfall of Bokaro and Dhanbad district (Fig. 15 & 16). The average temperature of the region is 26.1℃ and the annual rainfall is 1230mm (Bokaro district) and 1241mm (Dhanbad district). Due to heating of lands this region records highest average temperature among all other agro-climatic region. The red soil, clay soil and Loam soil are found more in this area. Clay soil is locally known as 'Kewal'. Generally, it is found on the deep don lands. Major crops of this region are paddy, maize, wheat, pulses, oilseeds etc. The soil has low water holding capacity which increases the problem of water for agriculture. Due to uncertainty of rainfall and uneven distribution, irrigation of crops is not done properly. This is the biggest problem of this region.

Agro-climatic Regional Planning for Sustainable Agricultural Development:

Sustainable agricultural development should be eco-friendly. The main purpose of development of agriculture is to increase the food production. Increase in food production can take place with the help of New Agricultural Technology. The main problems associated is low crop productivity and thus planning for agricultural development in each agro climatic region of North Chotanagpur plateau. In the study region due to high density of rural population and favourable agro-climatic conditions.

The North Chotanagpur Plateau Region dry is the main problems due to low rainfall and land surfaces of plateau, dense vegetation restricts the cultivation on limited areas. The Chatra, Hazaribag, Ramgarh, Koderma and Giridih districts show poor agricultural, low irrigation, low proportion net sown area as well as low cropping intensity, poor road network, low farm mechanization thus low productivity.

Due to plateau hilly area, agriculture is more difficult task in this region likewise agricultural practices obviously one found poorest among all the agro-climatic region needs special attention to the various agricultural extension services to provide better facilities in agriculture. Due to its complex terrain all the crops cannot be grown and give better yield without proper management. Therefore, with limited available resources, planning should be suggested for suitable cropping sequences. The suggested crop sequences are: wheat+ mustard, pulses+ Sanai, Sanai+ Jowar, Potato+ wheat and other crops. In hilly plateau areas, agriculture is not well performed due to unfavourable agricultural environment. Canal and surface water sources of irrigation are poor of North Chotanagpur Plateau. Due to stony surface and low groundwater table, tube well, well, tank, check dam irrigation facilities in this region. The check dams, construction of deep tube wells having water bearing strata deeper than 150-300 feet and deepening of existing wells are some suggestive measures to improve the irrigation only rainy season in this region. Small community tanks are also suggested for horticulture crops. In such areas, micro irrigation schemes like sprinkler or drip irrigation should be promoted for promoted for judicious utilization water.

All the districts of North Chotanagpur plateau show not good development in

agriculture. This agro-climatic region has the similar problems like seasonal dry depletion of ground water table etc. Besides these the moisture adequacy in the soil is also very low due to low rainfall. High irrigation intensity and intensive cropping leads to continuous deterioration in soil health. To sustain the soil health in future balanced use of fertilizers based on soil test have been suggested.

Suggestion for Sustainable Agricultural Development of North Chotanagpur plateau

The above discussion specific Agro-Climatic Regional Planning some common suggestions are proposed here for sustainable agricultural development of North Chotanagpur Plateau. For sustainable agricultural production in organic farming is better way in agricultural practices. This type of agriculture focuses on living soil on optimization of the use of biological process and on avoiding the use of synthetic chemical and fertilizers (Gautam and Bharadwaj, 2011).

It is mainly based on crop rotations, use of crop residues and the principal crops of Rabi seasons are gram, jowar, urad, kulthi and Kharif rice is the main crop. The main irrigation source is rainfall and other source canals, tanks, wells, dependent on rainfall. Irrigated area is about 7.2% of the total cultivated area in North Chotanagpur Plateau.

There is no time specific mechanization strategy of State government to accelerate the sustainable agriculture development. For increasing yields and cropping intensively agricultural mechanization policy should include and mechanization of the farms of all categories.

At many occasions there is crops failure by monsoon. Therefore, to stabilise income of farmers in disastrous year, government at district level should effectively implement the crop insurance schemes. Extensive Research and Development activities will be carried out to prepare crop and location specific advisories. It will include microclimatology, crop weather relationship including decision support system and crop weather models, weather-based forewarning of crops yields forecasting, early warning system of agricultural drought, agrometeorology and remote sensing, Climate change and agriculture etc (IMD vision 2030).

Conclusion:

The present study therefore has attempts to discuss and agronomic problems of North Chotanagpur Plateau. A projection of the needs of food, fodder and fibre for increasing population. The possibilities of sustainable agricultural development and provision of food security for rapidly increasing productivity per unit of agricultural areas. The major problems of all Agro-Climatic Regions are related with frequent occurrence of droughts. Looking into the region wise nature of problems some remedial measures for agricultural development have been suggested. These some suggested remedial measures will be agricultural development of North Chotanagpur Plateau.

Reference:

1. Sharma, V.P (2012): Accelerating agricultural development for inclusive growth, strategies issue and policy options: Vikalpa, vol-37 N0. 1 pp 1-17.
2. Wall, P. (2007): Tailoring Conservation agriculture to the needs of small farmers in developing countries: an analysis of issues. Journal of Crop Improvement 19: 137-155.
3. Gautam, H.R. and Bharadwaj, M.L (2011): Better practices for Sustainable Agriculture Health and Environment, Kurukshetra- Better Agricultural practices, A Journal on Rural Development, 59 (9), 49.
4. Rajgopalan, V. (1996): Agro- Climate Regional Planning in India, (Ed.) D.N. Basu and G.S. Guha, Vol. 1, Concept Publication, New Delhi, 179.
5. Singh, A. and Singh, B.N. (2011): Delineation of Agro-Climatic Regions in Eastern Uttar Pradesh, National Geographical Journal of India, 57 (u), 53.
6. Shafi, M (2006): Agricultural Geography, pp-371-374
7. Moshin, M.A. (1985): Watershed management plan, Tech. Bulletin Agr. Pp-64-65
8. Alagh, Y.K. (1983): "Agricultural Development Planning and Policies in the ESCAP Region" in Economic and Social Commission for Asia and Pacific, 1983. Experiences in Agricultural Development Planning in selected countries of Asia Bangkok, pp-15-28.
9. Govt. of India (1983): Report of the Agricultural Prices commission for the Rabi season 1983, Ministry of Agriculture and co-operation, New Delhi.
10. Govt. of India (1989): Agro-Climatic Regional Planning: An overview, Planning commission, New Delhi.

A Geographical Analysis of the Evolution of Grocery Stores into Shopping Centers in the City of Pune

Manisha Sanjay Pawar
Ph.D., Department of Geography, Shreemati Nathibai Damodar Thackersey Women's University, Karve Road, Pune, Maharashtra, India
E-mail: pawar123@gmail.com

Article DOI Link: https://zenodo.org/records/10559108
DOI: 10.5281/zenodo.10559108

Abstract:

The rapid expansion of urban areas and the increasing population growth are key factors associated with urbanization. The significant industrialization in urban areas and the growing population pressure have led to various adverse effects on the urban environment. Pune, one of the largest cities in India, is located between 18° 25" to 18° 37" North latitude and 73° 44" to 73° 57" East longitude. The study area covers the Pune Municipal Corporation, which spans 243 square kilometers and is divided into 14 administrative wards with a population of 4.30 million according to the 2011 census.

The lifestyle of the people in Pune city has been significantly impacted by population changes and urbanization. This has led to social, economic, cultural, and geographical changes. The grocery store business is part of the commercial sector, and the economic development of any region depends largely on the nature of trade in that sector. Different regions have different needs and demands, which in turn boost the production of goods. All production activities are linked to the market, where goods are made available to household consumers. Grocery stores, which provide essential food items, have evolved over time to adapt to changing lifestyles and economic factors, and have now transformed into malls.

Keywords: Grocery stores, Urbanization, Evolving lifestyles, Supermarkets.

Introduction:

Economic geography is a significant field within human geography, involving the thorough examination of human environments, the natural world, and commercial activities on Earth. The economic progress of a particular region is largely influenced by its trading characteristics, as financial transactions are essential for survival. Diverse regional needs and demands drive the production of goods, with markets playing a crucial role in facilitating the sale of these goods. All production activities are interconnected with markets, ensuring that goods reach consumers from various societal strata. A market is a space where factors that determine prices operate and ownership is exchanged through the direct exchange of goods. Markets can be classified based on sales volume, geographical area, volume of sales, period, and more. Grocery stores are

categorised based on the items they sell, and markets selling specific commodities are named after those commodities, such as cotton market, vegetable market, grain market, share market, gold market, and grocery market.

Small grocery stores:

A grocery store is a place that offers essential food items for daily human consumption. In addition to basic groceries, these stores also provide dairy products, bakery items, and prepared foods. Typically small in size, ranging from 500 to 700 square feet, these shops follow a traditional format for selling goods. They are commonly located in residential areas. In India, the number of grocery stores has increased from 0.25 million in the 1950s to 12 million today, largely due to population growth. The availability of items in these stores varies by region, with rural areas carrying mainly minor items, while urban stores offer a wider range including milk, bakery items, and ready-made foods.

Retail outlets: These shops sell a variety of general items to the public.

Wholesale outlets: These establishments supply wholesale or low-cost groceries to retail shops and consumers.

Supermarket structure: In response to increasing customer demand, the concept of supermarkets emerged in the 15th century to provide more convenient facilities. Supermarkets offer a wide range of processed ready-to-eat foods, as well as both raw and cooked food options in one location.

In India, supermarkets emerged after 1980, following the example of retail trade organizations in the United States. Recently, similar shops have been established in major cities in India, such as Super Bazaar in Delhi, which aims to offer high-quality essentials at affordable prices with an appealing product layout. Departmental stores catering to the elite's preferences have been around since the early 19th century, with examples like Karjarapeth, Parijatak, and Bharti Bazaar in Pune.

Mall Structure:

A mall is a large store that offers a wide range of goods and services. It caters to affluent consumers seeking high-quality products. This centralized approach allows small retailers to access a variety of goods under one management; making malls a hub for diverse inventory. Malls offer essential food items, luxury goods, and entertainment facilities all in one convenient location.

(A shopping mall, shopping centre, or shopping arcade is a complex of buildings containing stores and interconnected walkways, allowing visitors to move easily between stores. These walkways may be enclosed or open.)

Malls are located in urban and semi-urban areas with a customer-friendly design. They offer a wide range of high-quality products and strive to make shopping convenient and comfortable, while also providing entertainment facilities. Additionally, malls feature play areas and a variety of toys for children. In India, malls are expansive, covering

approximately 60 to 70 thousand square feet, and are typically situated outside urban areas.

Big Bazaar Mall in India was established in 2001 and is currently operational in 90 cities across the country. Subsequently, other malls such as D Mart, Hypermarket, Star Bazaar, More, Spencer, Reliance Fresh, and Spar Hyper city were also established. Additionally, Apna Bazaar and Century Bazaar are departmental stores in Mumbai.

All customers in the market have varying purchasing power and requirements. The nature of grocery stores is influenced by factors such as geographical location, population, urbanization, economic conditions, human attitudes, and evolving lifestyles, catering to the diverse needs of both rural and urban areas.The study subject is important as it focuses on the evolution of grocery markets to meet the changing economic and social needs of people. The design and format of grocery stores have adapted to become one-stop shops, catering to the daily needs of individuals. Supermarkets appear to differ depending on the economic and social status of the area. Over the 30-year period from 1990 to 2020, Pune transitioned from grocery stores to supermarkets. This industry holds significant economic importance. Post-2020, grocery stores gained prominence due to the COVID-19 pandemic, as they were the primary source of food supplies. Consequently, the significance and development of grocery stores have increased, with the availability of facilities such as online shopping.

Given the significance of the grocery market in people's lives, this topic has been chosen for investigation.

Changes and issues in the fundamental amenities of grocery stores.

The retail sector first embraced the culture of supermarkets and malls, followed by online shopping portals, which have placed the grocery and small business sectors in crisis. As a result of the growing commercialization and global competition in the 21st century, grocers have adapted the fundamental amenities of grocery stores to stay competitive. Likewise, grocery stores are evolving.

Employed individuals are often occupied with full-time work, leading to a heavy workload and limited time for personal and household tasks. This lack of assistance with housework and cooking creates a need for convenient solutions to overcome these challenges.

Previously, customers did not pay attention to the price of the goods as they were not itemized on the bill. However, now that the bill reflects the prices, customers are noticing the price increase. Traditional simple weighing forks have been replaced by electronic ones. Shopkeepers are adapting to meet customer demands by offering home delivery, online services, cashless payments, and entertainment. They are also ensuring the availability of fresh vegetables, fruits, and prepared foods by using a separate refrigerator. These efforts aim to maximise customer satisfaction.

Changes in supermarkets:

A supermarket provides food grains and everyday essentials to meet the basic needs of food, clothing, and shelter. This system evolves over time and in response to changing needs. In the 1970s, the grocery stores in the study area were quite limited in size, mainly selling grocery items. The central part of the city housed some large markets, while Pune city's Kasaba Peth, Sadashiv Peth, and Ganesh Peth areas had departmental store big grocery stores. These areas are part of the city's old quarter. Since 1981, grocery stores have been transformed into supermarkets, leading to an increase in the sale of various items beyond groceries. This includes dairy products, ready-made products, and bakery items. In areas such as Aundh, Hadapsar, Karve Road, and Ghole Road, the number of supermarkets has increased, resulting in the sale of a wider range of items.

Literature Review:

Pune city has been selected for a research study on its grocery stores and the economic geography associated with this topic. The research will involve a review of the grocery markets in Pune city, highlighting the significance of the research topic.

In a 1968 study by Fulop C, retail sales and consumer behavior in the City of London were examined. The study revealed a high demand for home delivery and ready meals due to the large number of working people in London. Additionally, it was found that online home delivery services are predominantly provided from malls to cater to the convenience of the high-end population in the city. The study also noted a low volume of retail sales.

In 1985, Barvarkar, V D conducted a comparative study of the changes in the rural areas of Pune city and the central part of the main Pune city. The study highlighted the high proportion of people living in slums during the period of 1950 to 1970 in Pune city. The areas in the Gavthan area and the old and urban areas of the city were identified, along with the rural areas. The population has increased, leading the Pune Municipal Corporation to incorporate the surrounding villages into the Municipal Corporation, resulting in the expansion of the city. In 1990, S. M. Karandikar studied the social and human life changes in Pune city. He emphasized the dynamic nature of human beings, adapting their lifestyle and habits according to economic and social changes. Karandikar briefly assessed the economic status of the people in Pune and categorized the standard of human life into four groups: very good quality, medium grade, status of inferior form, and poor quality. He collected statistics and examples for each category and concluded that the standard of living was moderate.

In 1981, Vrinda Malshe studied the Kothrud area of Pune city. The establishment of numerous industries in Kothrud led to a rapid increase in its population. The sector experienced significant growth, particularly with the rise in the number of IT companies. Kothrud is recognized as the fastest growing sector in Asia, with institutions such as

MIT, KirloSkar Company, Cummins Company, and educational institutes in Karvenagar contributing to the area's employment opportunities and subsequent increase in property prices.

Ruchi Shah (2007) conducted a comparative study between small grocery stores and malls, analyzing the advantages and disadvantages of both. The study found that despite the increasing number of malls, grocery stores are still important as they provide daily needs and immediate services. However, necessary changes are needed.

In a research report by Research and Markets (2011), factors affecting product sales in grocery stores were studied, including retail price, changes in goods' composition, and human lifestyle changes. The study concluded that changes in sales depend on the consumer.

Ekta Rani (2013) studied supermarkets and grocery stores, and found that the increasing attraction of consumers towards malls and government regulations have led to a decreasing number of grocery stores. The importance of supermarkets was demonstrated, as they offer a variety of choices and are designed to cater to the interests of customers. Necessary solutions were suggested considering the advantages and disadvantages of both grocery stores and supermarkets. He believes that supermarkets are a preferable alternative to grocery stores due to the declining business of the latter, necessitating a change in the structure of grocery store products.

Baheti Vidhi, (2015) "The analysis of consumers' attitudes towards online grocery shopping: a case study in the Indian context," conducted in Lancaster, UK. The article explores how consumers in the city of Lancaster show a stronger inclination towards online shopping compared to India. It highlights the increasing use of online facilities in developing countries like America, influenced by evolving lifestyles and financial considerations.

In 2021, Paul Ellickson and Paul Grieco examined the transformation of rural and urban markets from wholesale grocers to malls. Their study reviewed the progress of grocery shops from 1977 to 2002 based on the number of retail grocery shops and the number of supermarkets per 1000 population. It also compared the location and density of Wal-Mart stores between 1994 and 2006 with other grocery stores, noting that Wal-Mart stores are typically situated farther away from supermarkets and are more prevalent in upper-class residential areas. The study found that in 2006, grocery stores were generally within 3.5 miles, with 78% of people traveling to a grocery store within 5 miles. The research also analyzed the standard deviation of Wal-Mart stores based on the area's economic income levels, shedding light on the geographical scope. As Wal-Mart stores expand, they create employment opportunities, indicating that the location and structure of these stores are influenced by the region's economic conditions.

Nagrale, V. (2017), in "Geographical Assessment of urban utilities in Pune Municipal corporation region with changing urban population," explored the urbanization of Pune

city and the factors influencing it. The study highlighted the dynamic growth of urban areas and the increasing population as the most significant phenomena associated with urbanization, attributing adverse effects on the urban environment to large-scale industrialization and population pressure.

Bagas Aditya, (2020), "the impact of the Covid-19 pandemic on the informal economic sector in Indonesia: theoretical and empirical comparison", in this article, the study examines the impact of the Corona disease on the people in Indonesia. It identifies and discusses the problems that have been resolved.

Wagner Paul. D (2021) has conducted a study on Urbanization Processes in the Pune Urban Agglomeration. The study focuses on migration, economic and social factors in Pune city. It notes that the migration rate has increased due to the favorable climate, convenient facilities, and the development of education, finance, social and culture, and economic prosperity in Pune city. The availability of employment opportunities and the increase in educational institutions have further contributed to the migration of the working class, professionals, and students to Pune city, resulting in a rise in the population.

Hypothesis: The sales structure of grocery stores has been influenced by the evolving human lifestyle.

Aims and Objectives:

• To examine the new demands arising from lifestyle changes.

• To analyze the evolving sales patterns of grocery stores in the zonal division of Pune city.

• To investigate the transition from grocery stores to malls.

• To explore the causes and effects of changes in grocery stores.

Study Area:

Pune district is situated in the western part of Maharashtra state and comprises a total of 14 tahshils. Pune city, located in the Haveli taluka, has been chosen as the focal point for the study.

Physical factors:

Pune city is positioned at a latitude and longitude of 18° 25" to 18° 37" North and 73° 44" to 73° 57" East, with an elevation of 560 meters above sea level. Its topography resembles that of the Deccan Plateau, characterized by parallel lava layers. The highest points in the vicinity include Vetal Hill at 718 m and Sinhagad Fort at 1300 m. The city is traversed by the Mula and Mutha rivers, flowing from west to east and converging in the central area. Pune experiences a dry and pleasant climate, with average summer temperatures ranging from 25 to 40°C and average winter temperatures ranging from 15 to 30°C. The annual average rainfall is approximately 722 mm from the southwest monsoon. 14 zonal wards have been dismantled to facilitate the smooth operation of the Pune Municipal Corporation. The city's total area spans 243 sq. km, with

a population of 4,307,000 as of 2021.

Tourism:

Pune city boasts a rich ancient history and historical architecture, contributing to its allure for tourists. Notable historical sites in Pune include Kasba Ganapati, Jijamata Bagh, Shaniwar Wada, Aga Khan Palace, Lal Mahal, Osho Ashram, Raj Kelkar Museum, Shinde Chhatri, and Vishram Bag Wada. These historical landmarks attract numerous tourists to Pune, with the PMT Pune Darshan bus service catering to visitors.

Amenities and Facilities:

Apart from the essential human needs, the Pune Municipal Corporation has provided various facilities such as transportation, education, health, electricity supply, and entertainment centers to the residents of the city.

Transportation: Pune city offers various modes of transport including road, rail, and air. It is well-connected to other cities through national highways and state highways.

Rail Transport: Pune serves as a major junction on the broad-gauge line.

The city is also home to an international airport located at Lohegaon, approximately 10 km north-east of Pune.

Education: Pune is a significant educational hub in India, with institutions like Fergusson College, Savitribai Phule University, Bharti Vidyapith, and others contributing to its educational and research sectors. Additionally, Pune hosts several defense organizations, including the renowned NDA, AFMC, and CME, which provide training and education in various fields.

ARDE ERDL is a Defence Research Educational Institute that has witnessed significant development in research over the past 60 years. The city has become a popular destination for education due to its high-quality education and diverse range of courses, attracting students from both the country and abroad.

Healthcare in Pune is being actively improved by the Pune Municipal Corporation to meet the needs of the growing population. The city boasts municipal hospitals, dispensaries, family welfare centers, vaccination centers, maternity homes, and Matabal care centers, along with 50 private health centers and 528 health facilities.

The increasing urbanization, population, industry, and economy have strained the city's infrastructure, including power supply. To address this, the Maharashtra State Power Distribution Company has established the Lonikand station to meet Pune's primary electricity requirements.

Map of Study Locations:

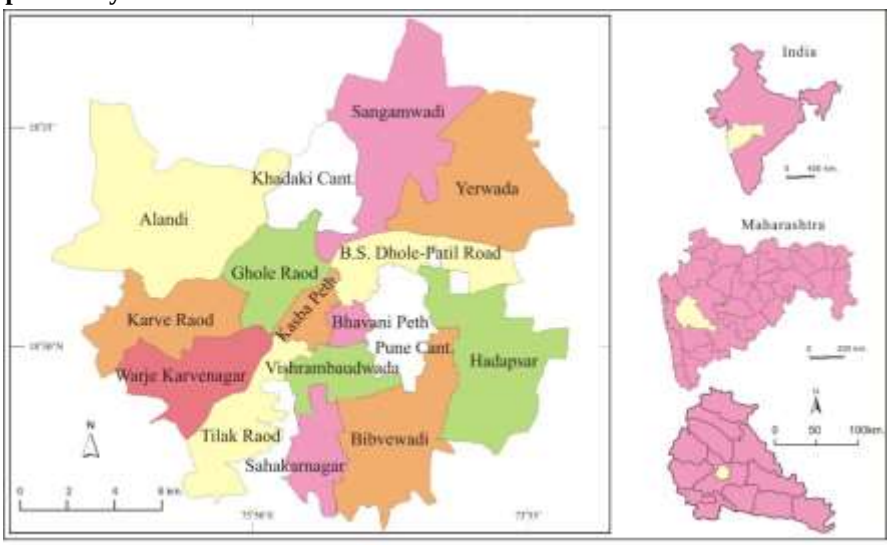


Fig. 1.1 : Location of the Pune

Research Methodology:

In Pune city, 14 zonal divisions of the Municipal Corporation have been chosen for the study of grocery stores. Various methods have been employed to analyze the changes in the grocery market from a geographical perspective. The traditional grocery stores have decreased in number, while supermarkets and malls have seen an increase.

Data Collection:

Primary data:

1. Direct interviews with shopkeepers in the study area have provided information on sales, customer demographics, and observations on shop appearance and product range.
2. Interviews with customers have yielded data on their financial status and purchasing patterns.
3. Observations: Written based on interviews and inspections, these observations detail changes in grocery store sales, encompassing general merchandise, vegetables, fruits, and prepared foods, from 1971 to 2021.

Secondary data:

Survey of India Toposheet No. SOI scale 1: 25000 (47 / F / 14 / 2, 47F / 14 / 3, 47F / 14 / 6, 47 / F / 15 / NE, 47 / F / 15 / NW) was used to determine the study area. Information was obtained from this map, as well as the statistics of total grocery shops from Pune Municipal Food Administration Department. Previous research on the study topic was studied from various theses, geographical research papers, Maharashtra Geography Research Papers, related books, magazines, and information about the regional divisions from the Pune Municipal Corporation Divisional Office. The total

population of the city and old statistics were compiled from study area information, census handbook, and gazetteer.

Sampling method:

In 2021, there were 3120 grocery shops in Pune Municipal Corporation, and 25 to 35 grocery shops were selected in each ward using an appropriate and systematic sampling method.

Preparation of bars and graphs:

Based on the statistics of the grocery stores in the study area, changes in the sales of the regional divisions during the period 1971 to 2021 have been presented in the form of line graphs. This study method was determined from the statistics obtained from various sources and the information obtained directly.

Changes in supermarkets in Pune city:

Introduction:

Markets are shaped by the preferences and needs of the people. Since the establishment of the Pune Municipal Corporation in 1950, the city has experienced significant growth in its infrastructure, population, and land use. As a result, the central area of Pune has undergone notable changes. While Kasba Peth and Budhwarpeth were previously central locations, Lakshmi Road now serves as the primary hub, with Tulshibagh and Kumthekar Road, Appa Balwant Chowk being prominent markets. The expansion of business into different segments, driven by software companies and educational institutions since 1997-98, has further transformed the landscape. Additionally, the grain market and timber market at Market Yard remain as the only surviving large-scale wholesale trades. In the eastern part of the city, Bhawani Peth and Nana Peth have emerged as key trade hubs, facilitating significant transactions of land resources

The Peths in Pune city include Shivajinagar, Sadashiv Peth, Narayan Peth, Shaniwar Peth, Budhwar Peth, Ravivar Peth, Kasba Peth, Guruvar Peth, Somwar Peth, Rasta Peth, Nihal Peth, Ganesh Peth, Nana Peth, Bhawani Peth, Ganj Peth, Guruvar Peth, Shukravar Peth, Gultekdi, and the suburban area. These areas are known for their concentration of various shops. The proximity of these Peths to Pune Railway Station and the presence of the oldest mandai in the city, Mahatma Phule Mandai, contribute to their significance. Ravivar Peth is particularly renowned as Saraf Katta. Over the years, the commercial landscape in Pune has evolved, with traditional co-operative department stores facing competition from modern malls and supermarkets.

The city has witnessed a significant increase in the number of grocery shops within the Pune Municipal Corporation, indicating the growing importance of grocery stores, particularly in the wake of the COVID-19 pandemic. This shift in the economic system has had a notable impact on the city's commercial sector and the nature of grocery retailing.

The transformation of grocery stores into supermarkets from 1971 to 2021 is as follows:

Average overall sales volume of products in grocery stores located in the city of Pune, (1971-2021).

Sr. No	Years	Milk and milk products (%)	Fruits and vegetable (%)	Readymade food (%)
1	1971-1981	0.3	0.3	0
2	1982-1991	1.9	2.8	1.0
3	1992-2001	20.4	8.8	16.2
4	2002-2010	28.3	11.8	25.7
5	2011-2021	71	57.3	76.2

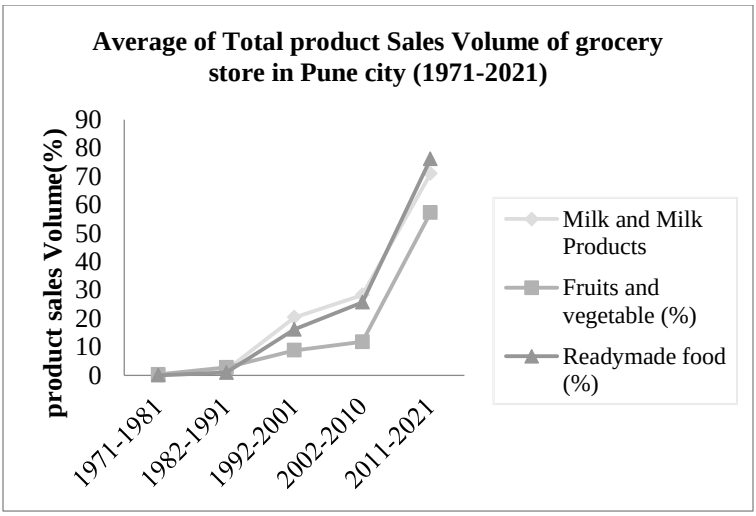


Table 1: Source of Direct Interviews

Between 1991 and 2011, the proportion of convenience food in grocery stores rose to 20% as a result of Pune's significant urban expansion, population growth, establishment of various businesses, and subsequent job creation. This led to an increase in dual-income households, limited time for domestic chores due to the nuclear family structure, and a growing demand for ready-made products in stores.

This trend gave rise to supermarkets offering dairy products, fruits, vegetables, and prepared meals in one location, including ready-to-cook items, spices, breakfast products, assorted flours, chapattis, and bakery goods. Over the decade from 2001 to 2011, the number of supermarkets substantially increased, providing customers with convenient facilities, high-quality products, various prepared foods, fruits, and vegetables, as well as home delivery and online services.

From 2011 to 2021, over 50% of grocery stores in supermarkets and malls transitioned to cashless systems due to urbanization, modernization, evolving lifestyles, and economic

conditions in Pune. Ready meals are now in high demand across all age groups, influenced by the rise of fast food culture, the presence of malls and Western influences, and the education of children in Western countries. Visiting malls has become a popular trend, and the younger, educated generation seeks efficiency, leading to a surge in demand for prepared foods from grocery stores.

As a result, the number of shopping malls in Pune began to increase. By 2011, there were 51 malls, and now there are over 150, indicating a threefold change in the nature of grocery stores within a decade. The rise of online shopping has been particularly notable in the digital age and has further accelerated in the wake of the COVID-19 pandemic. Consequently, grocery stores have adapted their product offerings to cater to evolving consumer demands.

While 70% of the stores have undergone changes, approximately 30% of them remain small in size, particularly in underdeveloped slum areas with lower economic status, where supermarkets are less prevalent in the rural outskirts of Pune. In summary, economic, social, and geographical factors have significantly impacted the grocery stores in Pune city.

Changes in Supermarkets: Reasons and Impacts

1. Social Changes: The shift from joint families to separate ones due to urban migration has reduced the manpower for household chores, leading to a demand for immediate assistance services. Supermarkets have adapted by providing prepared food items and convenient kitchen **products to cater to this need.**

2. Urbanization: The growth of cities has led to changes in land use, increased colonization, and a rise in population due to migration from other regions. These geographical and demographic changes have also impacted the economic landscape and consequently affected grocery stores.

3. Human perspective: The shift from suburban to urban living has influenced lifestyles, leading people to adopt a more Westernized approach and preferences. This desire to conform to perceived societal norms has influenced shopping habits towards malls and high-quality products.

4. Customer demand: The presence of a significant Western population in certain areas has led to a demand for specific goods, such as broccoli, bell peppers, mushrooms, and other Western food items and products. As a result, shopkeepers have adapted their inventory to meet these customer demands.

5. Economic Level: The purchasing patterns are influenced by the economic levels of different areas. For example, Gultekadi market attracts a larger number of farmers from villages, leading to the presence of Hamal Panchayat shops and Jhunka Bhakri hotels. This is due to the moderate economic level of the visitors. Conversely, areas like Aundh, Karve Road, and Hadapsar cater to the upper-class economic level, resulting in the presence of supermarkets, malls, McDonald's, and Pizza Hut. The economic level and

food preferences contribute to the diversity of shops in each area.

6. Lifestyle Changes: Evolving customer behaviors have shifted the shopping experience. Previously, customers would bring a list of goods to the store and personally inspect the items. However, modern urban life has led to men queuing for local buses in the mornings and an increase in women's employment. This has resulted in non-working individuals having to manage tasks such as fetching milk, transporting children to school, queuing for rations, and more. Working women also find it more convenient to shop during lunchtime or on their way to the office. Consequently, not only the location but also the timing of shops needs to be adjusted to accommodate these changes. Supermarkets have been designed to meet these evolving consumer needs.

Study Limitations:

In Pune city, Khadki Cantonment, Pune Cantonment, and Pimpri Chinchwad are separate Municipal Corporations that influence grocery stores in the study area. However, this study excludes these areas and focuses solely on the Pune Municipal Corporation (Pune City) area.

The Food Administration Department has mandated shop renovations for all retailers. This study only includes shops that have been renovated by the Food and Drug Administration Department until 2011.

The available statistics only cover a limited number of shops, and the statistics for the total number of shops are not satisfactorily available. Due to the impact of the covid -19 since 2019, the system lacks grocery store statistics and population statistics for 2021.

Recommendation:

To address the issues in grocery stores and malls in the study area, the following measures should be implemented:

- Grocery stores should stock products from well-known companies to increase trust.
- Use devices such as CCTV for customer safety.
- Provide facilities like schools and nurseries for the children of mall employees.
- Establish a primary centre or clinic in the mall for customer convenience, and create a customer forum to address their concerns.
- Provide professional education for workers to enhance customer service.

Conclusion:

- While social change is largely influenced by economic change, there is a significant influence of the imitation of the western way of life on social change.
- The city of Pune exhibits a widespread imitation of the western lifestyle, known for innovation and rapid fulfillment of basic needs.
- The importance of grocery stores has increased after events like the corona virus pandemic, leading to significant developments in online facilities.

- Supermarkets and malls have emerged from the transformation of grocery stores, influenced by geographical and economic changes driven by the growing population and new needs.

References:

1. Baheti Vidhi, (2015) "The analysis of consumers attitudes towered online grocery shopping a case study in Indian context," Lancaster University, UK.
2. Bagas Aditya, (2020),"the impacts of covid19 pandemic to informal economic sector Indonesia theoretical and empirical comparison, universities gadgets mead, Yogyakarta, Indonesia.
3. Berry, B. J. (1967) "Geography of market centers and retail distribution Edgewood cliffs, NJ.
4. Bird, A. & Sons Ltd, (1961), "Mrs. Housewife and her grocer, Geography and Retailing, Review literature, London.
5. Briggs, D.H, and Smyth, R.L., (1967) "Distribution of Groceries: Economic aspect of distribution of groceries with special reference to Western Australia, Perth, and W.A. pp-42.
6. Dahiwale Susvir (2010), "commercial Geography", first edition. Nirali Publication. Davies, R. L., (1968), "Effects of consumer income differences on the business provision of small shopping centers", Urban Studies, 5, pp. 144-64
7. Ekta Rani (2013), "Supermarkets vs. Small grocery stores", IOSR Journal of Business and Management, Vol 10.
8. EL-Adly, M.I (2007), "Shopping malls attractiveness: A Segmentation approach", International Journal of Retail & Distribution Management, no-35, Vol-936-950.
9. Kanabar Kavita (2012), "Change in consumer behavior in Surat with introduction of Mall", International Journal of Research in Finance & Marketing, Vol-2
10. Misra R.P (2002), "Increasing pressure if Population on Food Recourse in Madhya Pradesh", The Deccan Geographers Jan-June, Vol-40, pp 65-74.
11. Mc Anally, A.P., (1965), "Grocery trade in shopping centers", Journal of Industrial Economics, 13.pp. 193-204
12. Mc Cleland, W.G., (1962), "The supermarket and society", Sociological Review, New Series, 10, pp.133-44.
13. Mueller, W.F.and Garoian, L. (1961), "Change in the market structure of grocery retailing", Madison, Wisconsin.
14. Nagrale, V. (2017),"Geographical Assessment of urban utilities in Pune Municipal corporation region with changing urban population", S.N.D.T Women's University, Pune.
15. Parker, H.R., (1968), "The changing role of department store", Town Planning
16. Review, 39, pp.55-64.

17. Rajgopal (2012), "Growing shopping Malls and Behavior or Urban shoppers, Ph.D. Thesis.
18. Rakesh & Sapna, (2011), "Retailing in Indian Malls: Antecedents to retailer's for mall store space", Published in International Review of Retail, Distribution and consumer.
19. Roy Sayan (2010),” Role of slum in urban Development A case study of Pune city,” Pune University -2010
20. Sami A (1980), "Urban Market Geography", concept Publications, New Delhi.
21. Sawant S.B (1978), "The city of Poona A study in Urban Geography", Unpublished thesis, Pune university, Pune.
22. Saxena, H.M (1984), "Geography of Marketing concept and Methodology", staring
23. Schapker, B.L (1966), "Behaviour pattern of supermarket shoppers”, Journal of
24. Marketing, 28, pp.10-15
25. Shah Ruchi (2007), "Small Vs Mall", Project Report, University of Mumbai.
26. Publishers, New Delhi.

An Analysis of Factors Influencing In Adoption of Electric Vehicles By Buyers: A Case Study of Lucknow City

Jyoti Singh
Ph.D. Research Scholar Department of Commerce, Hemvati Nandan Bahuguna Garhwal University SRT Campus, Tehri, Uttarakhand, India
Email: Jyotisngh01@gmail.com
Krishna Kumar Verma
Professor & A. D.S.W., Department of Commerce, Hemvati Nandan Bahuguna Garhwal University SRT Campus, Tehri, Uttarakhand, India
Email: profkkverma3@gmail.com

Article DOI Link: https://zenodo.org/records/10559112
DOI: 10.5281/zenodo.10559112

Abstract:

It is a well-known fact that the use of diesel and petrol vehicles has increased rapidly during the last two decades. As a result, the environment has been polluted in the country which is an un-pleasurable atmosphere to human life. It has become necessary to see and develop Electric and Gas (LPG&CNG) Vehicles which may help to bring down the level of air and noise pollution for the human kinds. The present paper is related to factors influencing the adaptation of electric vehicles in the city of Lucknow. The factors that influence purchasing electric vehicles are studied with the help of the Consumer Adoption structural model. The major parameters are Technologies, Environmental, Infrastructure, and Price. The study has been carried out by authors and shown the importance of Electric Vehicles and government policies towards promoting Electric Vehicles and reducing the dependency on fossil fuels, greenhouse gases, and improving air quality around the world. The article focuses on consumer adoption, intention, and factors influencing purchasing the vehicles. A simple descriptive design for interpretation was used. The primary and secondary data were used. Secondary data were collected from different reports and primary data were collected through questionnaires from 121 respondents belonging to survey areas. Cronbach's Alpha Reliability Test was applied to test the reliability of the data collected. These data were analyzed effectively through SPSS Software. The results concluded that Electric Vehicles are good for our environment as well as human beings. The majority of the respondents have positive responses for the adoption of Electric Vehicles.

Keywords: Consumer Adoption, Technology, Environmental Concern, Infrastructure, Price

Introduction:

Electric Vehicles are those vehicles that get power from recharged batteries installed

inside the vehicles, instead of fossil fuel. The batteries are used for engine power, the functioning of wipers and lights. Electric vehicles are one of the eco-friendly products in the automobile industry.

Over the last decade, global warming is one of the major issues in the history of mankind, which is due to increasing the level of greenhouse gases in the environment. On account of greenhouse gases, there is air pollution and due to the mismanagement of wastes, there is degradation in the quality of land and water. Climate change is an alarm to the health of human beings regarding global warming. The introduction of Hybrid Vehicles (HVs) by automobile industries is an initiated challenge for tackling global gas emissions in the environment. Eco-friendly innovation is increasing in business, government agenda, and customer attention.

The introduction of new features of e-vehicles by the automobile industry has a positive impact on consumer willingness and acceptance /adoption of new vehicles. Due to increasing the rate of fossil fuel, electric vehicles are the better option from all concerns i.e. environmental protection, cost, and time effective.

The factors influencing the adoption of Electric vehicles may differ from place to place, region to region, rural or urban-based inhabitancy, hilly or plain, etc. In this study with the help of a structural model, we have measured the factors (as technology, environmental concern, infrastructure, and price of electric vehicles) influencing the adoption of electric vehicles in Lucknow city, Uttar Pradesh.

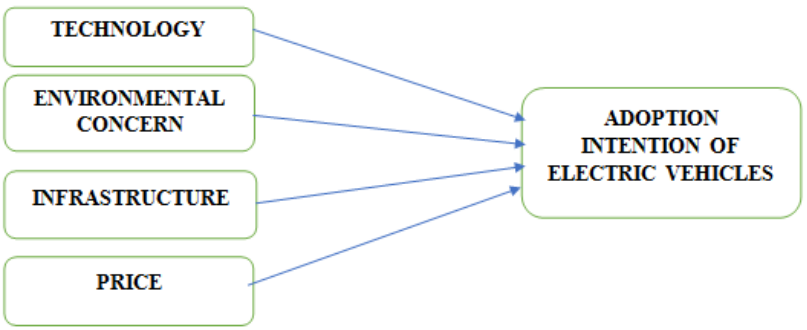
Technology-The term technology of e-vehicles understands that more advanced facilities are available in vehicles. Technology is one of the major factors that influence the adoption or willingness to purchase electric vehicles by customers.

Environmental Concern-The second factor taken in this article is an environmental concern. Electric vehicles are eco-friendly products that protect the environment from pollution and save the environment for future generations. The present consumer is more conscious about the environment and wants to buy a product that is favorable to nature. Environmental concern is the factor that influences consumers to the adoption of electric vehicles.

Infrastructure-The next factor is the Infrastructure facilities available for the smooth running of the electric vehicles, say, recharging point, and road facilities. Well-developed infrastructure is the factor that influences the adoption of electric vehicles.

Price-The last factor taken in this article is whether the price influences the consumer for buying electric vehicles, whether the price is reasonable, affordable, or favorable to buyers or not.

STRUCTURAL MODEL OF ADOPTION OF ELECTRIC VEHICLES



Sources: Prepared by the Authors

Literature Review

Wahab.L&et.al(2018) , case a study of Electric motorcycles in Northern Ghana examined which factor influences to adopt the electric vehicles. The study is based on a primary source of data. Multi-stage sampling technique was used for selecting a motorcycle. With the help of Simple Random Technique select the motorcycle owners for collecting data for the interview. Data were analyzed with the help of logit and probit regression willingness to adopt electric vehicles. The finding of the study that price , government subsidies, and performance are high usages and long distance is also impact to adopt the electric vehicles.

Verma, M.& et.al (2020), studies conducted in the city of Bengaluru, to identify which factors influence the consumer to buy electric vehicles. Data is collected through primary sources by the survey through a questionnaire based on Innovation Diffusion Theory. Environmental benefits, as well as financial benefits, are the factors influencing the purchase decision of Electric vehicles. The outcome of the study helps in policy making of electric vehicles which promotes and adoption of electric vehicles.

Zhang & et.al (2022), examined the comparative analysis of the regional heterogeneity in FST and TFT cities. The questionnaire method was developed to collect the data from 434 respondents from FST and 424 respondents from TFT. The help of Structural Equation model was used to compare the factor affecting the adoption of electric vehicles. The finding of the study is that attitude, subjective norms, novelty seeking, non-financial incentives, product cognition, and environmental concern are positively influencing both the cities purchasing intention of electric vehicles.

Bhattacharyya, S.S. and Thakre, S. (2021), studied factors influencing adoption of electric vehicles, focus on the emerging content of Indian economy .The author collected data through semi-structured open interviews from 38 experts including Electric vehicles

consumer and automotive industry.The finding of the study that's ecosystem factor that influences to adoption of electric vehicles in the Indian Market.

Objectives Of Study: To study the factors influencing to adopt the electric vehicles.

Research Methodology

This paper is prepared with primary data which were collected from 121 vehicle users. The list of vehicle users was prepared from the areas of Lucknow city. The 121 vehicle users were identified for detailed data collection with the help of a pre-tested survey schedule and questionnaire and personal interviews with vehicle users. For the collection of data from users, two-way interviews were followed i.e. personal interviews with the users and the second one was software (Through Google Forms/Digital media).The purposive sampling technique was followed for Primary data collection. Collected Data were classified into two groups i.e. male (85) and female(36) vehicle users. Data were analyzed according to age group, monthly income, occupation, a user having a driving license or not, Education level of the user of the vehicle, and consumer adoption index were calculated. . Customer willingness to the adoption of electric vehicles was considered as an explained variable while technology, environmental concern, infrastructure, and price were taken as explanatory variables which provides a suitable data set for analysis by using the multivariate model in the study. The technology adoption index of respondents was developed with the help of weightage given to individual views like strongly agree (5), agree (4), Neutral (3), Disagree (2), and Strongly disagree(1). The total score of individual respondents is multiplied by a hundred and divided by the number of questions of respondents. The result of the index has been considered with the help of the standard deviation and mean value of the major question reported by 121 respondents. The value of the score is divided into three groups lower index value, medium index value, and higher index value, and the whole respondent accordingly and considered for interpretation of the result.

Result and Analysis of Data

Table -1 Reliability Test and Cronbach Alpha

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.805	.787	20

1.(Source: Author's Primary survey data)

The reliability of the tool has been tested with the help of SPSS software. According to the above table, it has been seen that Cronbach's Alpha test was applied among 121 respondents & Reliability value of data was estimated at 0.805, which indicates good/best-fit reliability.

Demographic Parameters of Vehicle Users

The demographic parameters of the customers for adoption of electric vehicles

were as follows: Gender details of vehicle users, distribution of respondents according to age group with gender, and monthly income distribution of vehicle users. The adoption index of vehicle users is used in the data. The following tables describes the demographic parameters of the vehicle users i.e. sample size, education, income, gender-wise distribution of respondents, and age-wise distribution of respondents.

Table-2:Gender-wise distribution of respondents:

Gender	No. of Respondents
Total Male	85 (70.2)
Total Female	36(29.8)
Total Sample Size	121(100)

1.Authors'Calculation based on Primary Data .2.Figures in Parentheses indicate the percentage to total

The total sample size of the targeted group was 121 in Lucknow city. Male respondents were higher (85) representing 70.2 percent as compared to female respondents (36) having a share of 29.8 percent which is shown in Table -2.

Table-3:Age-wise distribution of male and female respondents:

Age Group	Male	Female	Total
<20	3(2.5)	1(0.8)	4 (3.3)
20-29	12(9.9)	7(5.8)	19(15.7)
30-39	26(21.5)	12(9.9)	38(31.4)
40-49	33(27.3)	15(12.4)	48 (39.7)
>50	11(9.1)	1(0.8)	12(9.9)
Total	85(70.2)	36(29.8)	121(100)

1. (Source: Based on Author's Primary survey data) 2. Figures in Parentheses indicator percentage to total

The above table shows the distribution of respondents in the four age groups which were i.e. age less than 20 years (first group), Above 20-29years(second group),30-39years(third group), 40-49 years(fourth group), and more than 50 years (fifth group), where the age group 40-49 years had higher respondents i.e. 48 persons belonging to 40 percent of the total respondents.

Table -4:Distribution of Respondents according to Monthly Income

Income Range (Rs. per month)	No. Respondents
Less than 25,000	**12(10)**
Above 25,000-50,000	**15(12.4)**
Above 50,000-75,000	**21(17.3)**
Above 75,000-1,00,000	**48(39.6)**
Above 1,00,000	**25(20.7)**
Total	**121(100)**

1. (Source: Author's Primary survey data) 2. Figures in parentheses Indicated percentage to total

The above table shows the distribution of sample respondents in the monthly income of

the household, which is divided into five categories i.e. less than 25000 first category, above25000-50000 second category, above 50000-75000 third category, above 75000-1,00,000 the fourth category and above 1,00,000 fifth category. The fourth category (above 75000-100000) vehicles users has the highest number of vehicles among all categories i.e. 39.6 percent followed by the fifth category i.e. 20.7 percent.

Table-5:Distribution of respondents as per driving License

Driving License	No. of Respondents
Yes	95 (78.51)
No	26(21.49)
Total	121(100)

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated percentage to total

The above table reveals the details of license holders who had purchased the vehicles during the studied period in Lucknow city.The 121 households interviewed who had purchased the vehicles during the last year 2021-2022. On interview, it was found that nearly 79 percent of customers had their driving licenses

Table-6:Profession-wise Distribution of respondents :

Occupation	Male	Female	Total(pool)
Student	5(4.1)	2(1.7)	7(5.8)
Self Employed	14(11.6)	4(3.3)	18(14.9)
Private Sector Employee	21(17.3)	7(5.8)	28(23.1)
Government Employee	35(28.9)	18(14.9)	53(43.8)
Other	10(8.3)	5(4.1)	15(12.4)
Total	**85(70.2)**	**36(29.8)**	**121(100)**

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated percentage to total

The above table revealed the distribution of respondents based on the nature of users of the vehicle. There are major five categories of respondents who are using vehicles during the survey period i.e. students, self-employed,private sector employee ,government sector and other doing jobs in some organizations. It is seen from the table that majority of the users of the vehicle are government employees while the least number is of the students.

Table -7:Education Level Respondent

Education Level	<20		20-29		30-39		40-49		>50		Total
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
High School	1(0.8)	0(00)	2(1.6)	1(0.8)	3(2.5)	2(1.6)	5(4.1)	2(1.6)	2(1.6)	0(00)	**18(14.9)**
Intermediate	2(1.6)	1(0.8)	3(2.5)	2(1.6)	6(4.9)	3(2.5)	10(8.3)	2(1.6)	3(2.5)	1(0.8)	**33(27.2)**
Graduation	0(00)	0(00)	2(1.6)	2(1.6)	5(4.1)	4(3.3)	12(9.9)	8(6.6)	6(4.9)	0(00)	**39(32.2)**
Post-Graduation	0(00)	0(00)	4(3.3)	2(1.6)	8(6.6)	3(2.5)	6(4.9)	3(2.5)	0(00)	0(00)	**26(21.5)**
Professional Course	0(00)	0(00)	1(0.8)	0(00)	4(3.3)	0(00)	0(00)	0(00)	0(00)	0(00)	**5(4.1)**
Overall	**3 (2.5)**	**1 (0.8)**	**12(9.9)**	**7(5.8)**	**26(21.5)**	**12(9.9)**	**33(27.2)**	**15(12.4)**	**11(9.1)**	**1(0.8)**	**121(100)**

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated percentage to total

The above table revealed the Education level of the male and female members of the respondent's families according to age groups. The Education level has been scaled into five (5) groups as mentioned in the table. It has been seen from the table that the majority of respondents (40 percent) having their aged 40-49 years have a better education level than that of other age group respondents. It is further noticed among different education levels of respondents the majority of vehicle users (32.2 percent) responds are graduate.

Adoption Index of Electric Vehicles

Maximum= Mean + SD

Minimum= Mean - SD

The formula used for the Adoption Index of Electric Vehicles

Consumer Adoption Index(CAI)= $\frac{\text{Total score consumer of the respondent}}{\text{No.of major factor}} x100$

Table-8 :Adoption Index of Electric Vehicles (n=121)

Group	Technology Adoption Index Value	Respondents
High	>More than 1538.64	38(31.4)
Medium	1355.56 - 1538.64	47(38.8)
Low	< Less Than 1355.56	36(29.8)

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated the percentage to total

The technology Adoption Index was developed with the help of four parameters and provided the weightage scale to individuals. The parameters of Vehicles were technology, environmental concern, infrastructure, and price. From the said table it has

been observed that the majority of respondents come in the medium groups (38 percent) followed by high (31 percent) and low 29 percent). This indicates that the majority of vehicle consumers were willing to purchase vehicles.

Table 9: Factors Influencing for Buying E-Vehicles across factors.

Factors	Overview of Buyers		
	Strongly Agreed	**Agreed**	**Neutral**
Technology	44(6.82)	377(42.84)	63(15.33)
Environmental Concern	187(28.99)	208(23.64)	89(24.09)
Infrastructure	256(39.69)	155(17.61)	73(17.76)
Price	158(24.5)	140(15.91)	186(42.82)
Total	645(100)	880(100)	411(100)

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated the percentage to total

It is to clarify here that each factors having four sub-question ,therefore total sub-question were 16.Hence,there are total sub-questions became1936 which were asked from the respondents and answered in the form of strongly agreed,agreed and neutral responses. From the above table, it is reveals that the view of buyers expressed their willingness to purchase of electric vehicles from different companies.It is seen from the table that well-infrastructure is one of the factors influencing for adoption of electric vehicles i.e. 256 (39.69 percent). It is followed by Technology (42.84 percent) and Environmental factors (23.64 percent). As per the rank-wise, the major factor influencing for purchasing of the electric vehicles by buyers is Technology i.e. 421 respondents(1) then Infrastructure 411 (2),Environmental Concern is 395 (3) and Price is 298 (4).

Table-10: Overview of buyers across factors for buying E-Vehicles

Factors	**Strongly Agreed**	**Agreed**	**Neutral**	**Total**
Technology	9.09	77.89	13.02	121(100)
Environmental Concern	38.64	42.97	18.39	121(100)
Infrastructure	52.89	32.02	15.09	121(100)
Price	32.64	28.92	38.44	121(100)
Overall	**33.32**	**45.45**	**21.23**	**121(100)**

1.(Source: Author's Primary survey data) 2. Figures in parentheses Indicated the percentage to total

The above tables show the views of buyers for purchasing vehicles from different companies/agencies. There are major four factors influencing the choice of buyers at the time of purchasing e-vehicles.The study has been carried out in Lucknow city and 121 e-vehicle purchasers were interviewed. Among technology, the majority of the buyers were in favour of the good quality of technology while only 13 percent of buyers have not been given any choice of the technology and only 9 percent of buyers expressed their strong feeling of quality vehicles.This indicated that only a few buyers prefer the quality of the vehicles and they do not agree to compromise with the quality of

the vehicles.In case of environmental concerns buyers are very much conscious of diesel and petrol vehicles which are creating air pollution as well as noise pollution.These are harmful to human health affecting different types of environmental concern diseases which are directly affecting to human life.Nearly 42 percent of buyers agreed for purchasing e-vehicles while 38 percent were strongly in favour of purchasing e-vehicles.And rest of them having no comments about the knowledge of the environment.These buyers may belong to non-urban area. Poor Infrastructure is one of the major factors not supporting to purchase of e-vehicles. The price of e-vehicles is one of the important factors affect the sale of e-vehicles.Among four factors,it is seen that 19.47 percent buyers agreed quality /good technology vehicles and 13.22 percent strongly expressed their view regarding available poor facility of infrastructure and nearly 11 percent buyers have given their view about environmental and only 9 percent expressed their view the price of vehicles.

Limitation:

1.Language is one of the limitations faced by surverer during data collection.

2.Cost of data collection is another limitation.

3.Lack of Local cooperation of local people/leaders during data collection is also a constraint.

4. Time is one of the constraints faced by surverer during data collection.

5. Transport Infrastructure /mode of transport was a constraint faced by surverer.

Findings:

From the study,it is found that the majority of male respondents were higher (70.2%) as compared to female respondents(29.8%).It is seen that mostof the vehicle users were doing permanent job somewhere in government departments and others users were also doing job somewhere in reputed private industries.The monthly income of the targeted group was recorded (Rs75000-Rs 100000) of thefourth category(39.6 percent) followed by the fifth category (29.7 percent) of the sample households.Regarding the technology vehicles which are related to the different features available in the vehicles,the buyers choice preference good quality and multi-technology features exist in the vehicles. Surprisingly 13 percent buyers have not expressed their choice regarding technology features.The environment is the important factors having relation with quality of e-vehicles which is not having any relation with pollution both air and noise in the city areas.While pollution conditions are not existing in rural areas.It is well known that to the e-vehicles users/buyers. It is clear from the study that 42 and 38 percent of buyers express their views agreed and strongly agreed respectively.Infrastructure facilities in which including charging facilities,road conditions and service centers available in the areas. From the study, it is clear that poor infrastructure facilities are hindrances/disappointing to the to purchaser/buyers. The 13.22 percent of respondents expressed the view that they strongly agree with the existing infrastructure facilities

because charging facilities may be available at their door and these respondents may have other substitutes mode of communication at their own levels. But e-vehicles may be the fashion of such families or such vehicles may be the icon.The poor infrastructure facilities may be a hindrance for rural peoples for purchasing E-vehicles. The well-infrastructure (i.e. charging point, metalled road) is one of the factors influencing the adoption of electric vehicles before going to purchase.As far as concerned of the price of e-vehicles, 9% percent respondents expressed their views on the price which may be the problem for purchasing e-vehicles. It is also known from the survey experience that due to the higher price of diesel, and petrol vehicles, purchaser move to adopt of e-vehicles or they shifted their willingness to purchase e-vehicles in place of non-electric vehicles.

Conclusion:

It is concluded that new or advanced facilities existing in e-vehicles influence customers to adopt electric vehicles. As electric vehicles are environmentally friendly and have a feature of zero pollution in nature, it is easily adopted by society. However, poor infrastructure facilities are the barriers which has a negative impact on purchasing e-vehicles. The price of e-vehicles may be higher as compared to fuel vehicles. Electric vehicles are of advanced features and less pollution in nature which may be environmentally friendly, provide clean environment for the next generation.

Reference:

[1] Acharya Sajan (2019),'Consumer Perception Electric vehicles Industry –A study on the Role of Electric Vehicles on Environmental sustainability'Journal of Emerging Technologies and innovative Research (JETIR),www.jetir.org (ISSN-2349-5162),JETIRCB06012

[2] Bennett Roger and Vijaygopal Rohini (2017),'Consumer Attitude towards electric Vehicles –Effects of products user Stereotypes and self–image congruence ',European Journal of Marketing, Emerald Publishing Limited www.emeraldinsight.com/0309-0566.htm, DOI10.1108/EJM-09-2016-0538

[3] Bhattacharyya, S.S. and Thakre, S. (2021), "Exploring the factors influencing electric vehicle adoption: an empirical investigation in the emerging economy context of India", *Foresight*, Vol. 23 No. 3, pp. 311-326. https://doi.org/10.1108/FS-04-2020-0037

[4] Bhutto Maqsood hussain, Tariq Beenish, Azhar sarwar, Ahmed Khalid and Khuwaja Faiz Muhammad and Han Heesup (2019),Predicting consumer purchase intention towards hybrid Vehicles:Testing the moderating role of price sensitivity .European Business Review,Emerald Publishing Limited,DOI 10.1108/EBR-10-2019-0274, https://www.emerald.com/insight/0955-534X.htm

[5] Bhalla Pretty, Salamah Ali Inass and Nazneen Afroze,(2018)'A study of consumer Perception and purchase Intention of Electric Vehicles,European Journal of Scientific Research ,ISSN1450-216X/1450-202X Vol.149 No 4 July,2018,pp.362-368, http://www.europeanjournalof scientificresearch.com

[6] Manutworakit, P., &Choocharukul, K. (2022), Factors Influencing Battery Electric Vehicle Adoption in Thailand—Expanding the Unified Theory of Acceptance and Use of Technology's Variables. *Sustainability*, *14*(14), 8482. https://doi.org/10.3390/su14148482

[7] Naor Michael, S. Bernardes Ednilson , T Druehl Cherl and Shiftan Yoram (2015),"Overcoming barriers to adoption of environmentally -friendly innovations through design and strategy",International Journal of Operation & Production management ,Vol.35 Iss 1pp 26-59,Emerald Insight,www.emeraldinsight.com0144-3577.htm,DOI10.1108/IJOPM-06-2012-0220,Emerald Group Publishing Limited 0144-3577

[8] Varghese Ajex Thomas, Abhilash V.S and Abhilash Sini V (2021),A study on consumer perception and purchase Intention of Electric Vehicles in India,Asian Journal of Economics,Finance and Management 4(2):13-25;Articles no. AJEFM.434

[9] Tube omkar, kishore Shweta and Johneira Arloph (2020),Consumer Perception of Electric Vehicles in India.European journal of Molecular & Clinical Medicine ,ISSN 2515-8260

[10] Verma, M., Verma, A., & Khan, M. (2020), Factors Influencing the Adoption of Electric Vehicles in Bengaluru. *Transportation in Developing Economies*, *6*(2), 17. https://doi.org/10.1007/s40890-020-0100-x

[11] Wahab I. & Jiang H (2019), Factors Influencing the adoption of Electric vehicles: The Case of Electric Motorcycles in Northern Ghana, International Journal for Traffic and Transport Engineering,9(1),22-37. https://doi.org/10.7708/ijtte.2019.9(1).03

[12] Zhang, J., Xu, S., He, Z., Li, C., & Meng, X. (2022), Factors Influencing Adoption Intention for Electric Vehicles under a Subsidy Deduction: From Different City-Level Perspectives. *Sustainability*, *14*(10), 5777. https://doi.org/10.3390/su14105777

An Analytical Study of Use Organic Fertilizers in Agricultural Development

Balasaheb Raghunath Chakor
Asst. Professor, Department of Geography, K.V. N. Naik Arts, Commerce and Science College, Nashik 422002, Maharashtra, India
E-mail- balasahebchakor01@gmail.com
Pakhale Kishor Devidas
Incharge Principal & Asst. Professor, Department of Commerce, K.V. N. Naik Arts, Commerce and Science College, Nashik 422002, Maharashtra, India.
E-mail- pakhalekishor@gmail.com

Article DOI Link: https://zenodo.org/records/10559196
DOI: 10.5281/zenodo.10559196

Abstract:-

Organic farming is a method of integrated farming that avoids the use of chemical fertilizers by studying the ecological structure and life cycle of living organisms. The soil is becoming hard or hard as a result of the excessive use of chemical fertilizers and drugs. The use of chemical fertilizers has begun to reduce farmland fertility. Using organic farming methods to sustain agriculture lowers the cost of chemical fertilizers and medicines. Organic fertilizers and medicines are less expensive for farmers to use in organic farming. The use of organic fertilizers is unquestionably beneficial in increasing land productivity.

This also applies to the crop produced from it. The use of organic fertilizer's results in significant financial savings. The use of these fertilizer's has a positive impact on crop growth and quality. Organic farming reduces soil erosion by using traditional seed, dung-cow urine, and traditional tillage techniques. Continuous cropping and the overuse of chemical fertilizer's deplete the soil's nutritional value. As a result, crop production begins to decline. The use of organic fertilizer's and nutrients is essential to compensate for the soil's nutritional deficiency. Plants require nutrients, which are found in organic materials and fertilizer's. As a result, organic materials or fertilizer's produced in many natural ecosystems such as cow dung, compost manure, green organic fertilizer's, green manure, vermicomposting, and bone manure are used as organic fertilizer's to increase agricultural productivity. Organic fertilizer's also play an important role in organic farming to improve soil degradation.in this paper we are using the SPSS software for calculation of chi square test and percentage calculation.

Keywords:- green organic fertilizers, medicines, soil, nutritional values, chemical fertilizers

Introduction:-

In the competitive world we are ignore the quality of product and we are going to the mass production or less quality product. This is applicable in all fields like

manufacturing, agriculture. but in the manufacturing sector there is no natural resource to improve naturally mass production , improve naturally high quality product and naturally no side effect product. But in agriculture filed there is one remedies is available is call as traditional or organic farming. In the traditional agriculturesystem the organic fertilizer is play very important role.

The term "organic" refers to a labeling term that denotes a food or other agricultural product made entirely of natural ingredients. Organic products must ensure that they preserve ecological balance and biodiversity, promote resource cycling, and support a healthy environment, from biological to mechanical to cultural practices. Using organic products for gardening, farming, and agriculture has numerous environmental and safety benefits.

Nitrogen, phosphorus, and potassium chemical fertilizers with nutritional value are used in large quantities in agriculture due to the desire to increase the productivity and yield of the land by using chemical fertilizers and improved seeds. In recent years, excessive fertilizer use has resulted in an imbalance in micronutrient value. As a result, land productivity is declining. Excessive use of nitrogenous and phosphorous fertilizers in soil has created an imbalance in ecosystems such as reservoirs and ponds. The use of excessive chemical fertilizers has become a major headache for farmers as a result of green revolution technology and the desire to maximize yield. To address this issue, organic farming practices and the use of organic fertilizers are essential.

According to Sir Albert Ha Ward, the father of organic farming, organic fertilizers increase soil fertility and improve soil health. The use of organic fertilizers in the soil increases soil productivity and aids human health by providing healthy and nutritious substances. Adoption of organic farming is therefore urgently required. The use of organic fertilizers and nutrients is essential to compensate for the soil's nutritional deficiency. Plants require nutrients, which are found in organic materials and fertilizers. As a result, using organic materials or fertilizers produced in many natural ecosystems such as cow dung, compost manure, green organic fertilizers, green manure, vermicompost, and bone manure as organic fertilizer’s to increase agricultural productivity and Organic fertilizers are essential in organic farming for soil degradation improvement.

Definition of organic fertilizers: -

1. Organic fertilizers are biological substances obtained from the decomposition process of microorganisms on animal and plant material such as animal dung or excrement.

2 Fertilizers made from the remains of plants and animals are called organic fertilizers. These include manure, compost, vermicompost, fish manure etc.

3 Organic fertilizers are processed from animal matter, animal excreta and human excreta as well as vegetable matter. "Organic fertilizers are mineral sources that occur in nature and contain adequate amounts of plant nutrients."

Organic fertilizers are made from plant-derived sources, which can be fresh or dried plant material.

In short, an organic or organic fertilizer is a fertilizer with nutritional value made from naturally available material without any processing.

Characteristics of organic manure: -

1 Organic farming is a sustainable and environmentally friendly production process

2. Maintaining fertility in the soil and increasing production by improving the physical, chemical and biological properties of the soil due to the use of organic fertilizers.

3. Use of organic fertilizers maintains soil fertility

4. Organic fertilizers help increase the number of beneficial bacteria in the soil.

5. Helps increase the water holding capacity of the soil.

6. Aeration helps the soil to meet its nutrient requirements through organic fertilizers.

Types of Organic Manure:-

Plant and vegetable waste, animal matter, excreta and mineral sources are used to produce organic fertilizers. Organic fertilizers have a complex biological structure, which is one of their main advantages.

1.Compost Fertilizers:- Organic waste decomposed by composting is called Compost fertilizers. Examples of organic materials are vegetable and plant waste, as well as animal excrement. Compost is produced by the process of decomposition of animal and vegetable matter, crop mulch, urban excrement and other waste materials. All these residues are decomposed by aerobic and anaerobic microorganisms. This fertilizer contains nitrogen 0.5%, phosphorus pentoxide 0.15% and potassium monoxide 0.5%. It contains all the three nutrients required by plants. It is widely used for gardening. Most importantly, this fertilizer can be made at home. It is made with little effort, in little space, and thus reduces household wet waste. This fertilizer can be used for all types of plants. When mixed with soil, it improves soil texture and quality. This fertilizer is mixed in the soil before planting. When wet grass is spread over it, the land becomes fresh. This nutrient water can be given to plants as compost tea, and sprayed on the leaves. Even as a hobby, anyone can make this fertilizer with the knowledge.

2. Manure: - Manure is produced by the decomposition of animal dung and plant residues. These residues are collected from the animal sheds on a daily basis and deposited in a pit for decomposition. It is assumed that organic manure has been produced when the rotted residue in this pit turns black. Nitrogen is present in well-decomposed organic manure. 0.5%, 0.15% phosphorus pentoxide, and 0.5% potassium monoxide. However, it is regarded as an excellent organic fertilizer. This is because it is readily available and inexpensive. Composting is a method of breaking down materials. When a substance decomposes, it emits a variety of gases. Using composted manure instead of fresh manure reduces environmental risk by producing fewer greenhouse gases. Second, composting eliminates ammonia gas. Ammonia petrol has the potential to

burn plant roots. Composting cow dung is more beneficial than applying it directly. Weed seeds are present in cow fodder, and even if they enter the cow's stomach, they are not digested. As a result, if this dung is fed to plants, these seeds will germinate, increasing the likelihood of weed growth. However, these seeds will not germinate in the compost. As a result, the main advantage of such fertilization is that the risk or nuisance of weeds is reduced.

3. Green organic fertilizers: -

For green organic manure, fast-growing leguminous crops are planted in the field. These crops are ploughed in and buried in the field, contributing to the improvement of the soil's physical properties. It boosts the land's productivity. They are referred to as green organic fertilizers. This green organic manure is made from crops such as jute and flax. Green organic manure improves the soil's nutritional value. The erosion of soil particles is reduced by binding them together.

4. Blood Meal or Blood Meal Fertilizer: – This is a good form of organic fertilizer with a nitrogen, phosphorus and potassium ratio of 12-1-1. The blood of slaughtered animals is used for this fertilizer. This blood is dried and powdered to be used as fertilizer or plant food.

5. Fish feed fertilizer: - This fertilizer is called as a rounder organic fertilizer. The proportion of nitrogen, phosphorus and potassium in this fertilizer is 5-2-2. This fertilizer is used for different types of plant growth. All bones, skins, scales or waste parts of fish are used in this fertilizer. When the fish rots, its nutrients are released and are beneficial for plant growth.

6. Sea bird faces fertilizer: - This fertilizer contains a 10-10-2 ratio of Nitrogen, Phosphorus, and Potassium. These fertilizers also contain other nutrients and vitamins required by the soil in small quantities. So it is important as a good organic fertilizer.

7. Chicken Poultry Fertilizer: - Nitrogen, Phosphorus and Potassium ratio in this fertilizer is 4-2-1. These fertilizers are readily available in the market in the form of powder or dried pellets. This fertilizer is more beneficial to the plants during leafing period.

8. Vermicomposting: - Vermicomposting is known as a very useful and effective and boon organic fertilizer for organic farming. The ratio of nitrogen, phosphorus and potassium in this organic fertilizer is 1 – 0 – 0. In other words, it can be said that it has low nutritional value. But this fertilizer is useful for maintaining soil humus, resulting in aeration of the soil, plant roots. This improves soil texture and provides better nutrition to plants. Along with soil, it is widely used in potted plants, container grown plants, indoor plants and compost piles.

9. Sarki Feed Fertilizer: - It has 6-1-1 ratio of Nitrogen, Phosphorus and Potassium. This organic fertilizer has a very good nitrogen content. It is a good fertilizer when the plant is leafing. Adding manure to the soil and adding wet grass over it gives enough

time for the nutrients in the sap to leach out.

10. Bat dung: - The ratio of nitrogen, phosphorus and potassium in this fertilizer is 10 – 10 – 2. The use of this fertilizer is beneficial for leafy vegetables, flowers and fruit trees. Of course, the nutrients in this food vary depending on what the bats eat. Bats mostly eat insects. Bats that eat more insects have a higher nitrogen content in their diet. But bats that eat fruit have higher levels of phosphorus in their feed or fertilizer.

Also includes a feather meal, bone meal, shell meal, corn gluten meal, sea weed.

Advantages and Disadvantages of Organic Fertilizers: -

Fertilizers are used to make the growth of crops, plants, trees healthy and the fruits, flowers or other products obtained from them are of good quality. While choosing a fertilizer it is necessary to understand its advantages and disadvantages. Whether that fertilizer is chemical, synthetic fertilizer or organic fertilizer. If you understand the difference between both chemical and organic fertilizer, it becomes easy to choose the fertilizer. We will study the advantages and disadvantages of organicfertilizer's in this section.

A. Advantages of Organic Manure: -

1. Organic fertilizers are nature-friendly as well as in harmony with the cycles of nature.
2. Organic fertilizers help hold soil particles together.
3. Organic manure increases the amount of nutrients in the soil.
4. There is a wide variety of organic fertilizers.
5. Organic fertilizers are environmentally safe.
6. Organic manure can reduce pollution. It does not cause much damage to the environment
7. The use of organic manure improves the soil condition
8. Organic manure increases the yield percentage significantly.
9. Organic fertilizers are easier to use.
10. Organic fertilizers are lighter in weight compared to chemical fertilizers. Its uses help in keeping the soil humus. So the soil as well as the roots of the plants get enough air.
11. The biggest advantage of organic fertilizers is that they can be made at home. Wet kitchen waste such as vegetable stalks, food scraps, and fruit peels can be composted. Those who have a garden at home can make organic fertilizer using wet grass from the garden, a mulch of trees, and if they have cattle, their excrement.

Disadvantages of organic manure: -

1. There is little specialization in the nutritional value of organic manures
2. Organic fertilizers are bulky and difficult to handle and transport.
3. The nutritional value of organic manure is released slowly.

Importance of organic manure: -

Organic fertilizers may be applied in a variety of ways in the garden or soil. This fertilizer can be made using a proprietary composting technology. Organic manure has a

high capacity for moisture absorption: The organic manure pellet absorbs a lot of moisture after composting. It has a long lifespan: Organic manure can be easily and indefinitely stored. Nutrients are released gradually, giving plants time to recover: Organic fertilizers release nutrients gradually, allowing the crop to absorb them as it grows. Organic fertilizers can be applied at any time of year and in any season. Organic fertilizers promote gardening by maintaining the fertility of the soil, plants, and beneficial insects.

Organic fertilizers can help your farm and garden grow a bumper crop of vegetables or flowers, allowing them to reach their full potential. Your plants and vegetables will benefit from a balanced, nutrient-rich ecosystem that can function as nature intended when you use organic fertilizers. Because of their low concentration, organic fertilizers are safer to use than synthetic fertilizers. Organic fertilizers are the best agricultural fertilizers for plants and crops because they are non-toxic and environmentally friendly. Their regular use has no negative environmental impact and contributes to a brighter future. Organic fertilizers contribute to the degradation of other natural substances in the soil and help to eliminate unwanted and dangerous environmental contamination.

Organic fertilizers are the way to go because they are biodegradable, renewable, long-lasting, and environmentally friendly. Today's market is flooded with high-quality organic fertilizers. Their high-quality products are used to help strengthen plants by farmers, landscapers, gardeners, and homeowners all over the world.

Research Objectives: -

1. To study the importance of organic fertilizers in agricultural development.
2. To study the advantages and disadvantages of organic fertilizers.
3. To study the income level of the farmers.

Hypothesis: -

1.There is significant relation between use of Organic fertilizer and income level.
2.There is 60% farmers agree organic fertilizer is help to farm.

Research Methodology

Data Collection: -

In this paper the data was collected by primary and secondary resources.

In the primary data we created the questionnaire. This questionnaire was circulated 385 farmers as per the sample size .and given 10 minutes to each participants to fill-up these questionnaire.

The secondary data was collected from various books, website and journals and research papers and also used on a variety of periodicals, reference books, agricultural diaries, other sources etc.

Data interpretation: -

In this study data is collected qualitative and quantitative data with the help of a descriptive research approach, the variable test in this study using SPSS software and

various tests isused. This study we used the chi square test to check is there any significant relation between two variables.

H1.There is significant relation between use of Organic fertilizer and income level.

TABLE 1.00 Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.058[a]	2	.589
Likelihood Ratio	1.036	2	.596
Linear-by-Linear Association	.043	1	.835
N of Valid Cases	385		
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.50.			

In the TABLE 1.00 is the Chi-Square Test table this table shows person Chi Square value is 1.058[a] , Likelihood Ratio value is 1.036, Linear-by-Linear Association value is 0.43 & n Of valid cases value is 385 and Degree Of Freedom(df) is 2,2,1.

In the TABLE 1.00 Asmp.Sig. (2-sided) is the calculation of the chi square the significance value is .589,.596,.835 it is the greater then 0.05 that's why the **reject H1**. There is significant relation between use of Organic fertilizer and income level. And **Accept H0**. There is no significant relation between use of Organic fertilizer and income level.

H1. There is 60% farmers agree organic fertilizer is help to farm**.**

TABLE 2.0 PERCENTAGE CALCULATION					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	374	97.1	97.1	97.1
	NO	11	2.9	2.9	100.0
	Total	385	100.0	100.0	

In the table 2.0 is the percentage calculation table. This is the survey report. This table shows farmers are agree or not agree organic fertilizer is help to farm. The YES frequency is 374 and percentage is 97.1, valid percentage is also 97.1 and Cumulative Percentage is 97.1. The NO frequency is 11 and percentage is 2.9, valid percentage is also 2.9 and Cumulative Percentage is 2.9.

The table 2.0 calculation shows how many farmers are agreed the using the organic farming is helpful to farm. According to the table 2.0 the 97.1% farmers are agreeing organic fertilizer is help to farm. according to this result we are accept the **H1.** There is 60% farmers agree organic fertilizer is help to farm.

Conclusion: -

We are concluded that we agree organic fertilizers is help to the farm but this is

not impact to the income level of farmers. But this is one side other side more than this Raising public awareness about organic fertilizers among tribals and smallholder farmers in rural areas is critical. Organic fertilizers are created using resources available to farmers. Given the recent negative effects of chemical fertilizers, farmers should adopt the mindset of using organic fertilizers in large quantities. At the government level, it is critical to raise public awareness and provide subsidies for farmers to use these fertilizers. Overall, organic farming based on organic fertilizers will promote human health and environmental balance.

Reference: -

1. An analytical study of use Organic Fertilizers in Agricultural Development - Google Search. (n.d.). Retrieved December 3, 2023, from https://www.google.com/search?q=An+analytical+study+of+use+Organic+Fertilizers+in+Agricultural+Development&sca_esv=587427479&authuser=1&sxsrf=AM9HkKkUB4Oq7Hl0gLr4LQ54OFTYgstPng%3A1701601176532&source=hp&ei=mF9sZaW2HqHm1e8Po9CY-Aw&iflsig=AO6bgOgAAAAAZWxtqAdiiCCo-2mcM8lPVFvs7GCxtTnN&ved=0ahUKEwil4rKtjvOCAxUhc_UHHSMoBs8Q4dUDCAo&uact=5&oq=An+analytical+study+of+use+Organic+Fertilizers+in+Agricultural+Development&gs_lp=Egdnd3Mtd2l6IkpBbiBhbmFseXRpY2FsIHN0dWR5IG9mIHVzZSBPcmdhbmljIEZlcnRpbGl6ZXJzIGluIEFncmljdWx0dXJhbCBEZXZlbG9wbWVudDIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJzIHECMY6gIYJ0ilMVCtHVitHXABeACQAQCYAQCgAQCqAQC4AQPIAQD4AQL4AQGoAgo&sclient=gws-wiz
2. Barthès, B., & Roose, E. (2002). Aggregate stability as an indicator of soil susceptibility to runoff and erosion; validation at several levels. Catena, 47(2), 133–149. https://doi.org/10.1016/S0341-8162(01)00180-1
3. Boafo, D. K., Kraisornpornson, B., Panphon, S., Owusu, B. E., & Amaniampong, P. N. (2020). Effect of organic soil amendments on soil quality in oil palm production. Applied Soil Ecology, 147. https://doi.org/10.1016/J.APSOIL.2019.09.008
4. Brookes, P. C. (1995). The use of microbial parameters in monitoring soil pollution by heavy metals. Biology and Fertility of Soils, 19(4), 269–279. https://doi.org/10.1007/BF00336094
5. Cen, Y., Guo, L., Liu, M., Gu, X., Li, C., & Jiang, G. (2020). Using organic fertilizers to increase crop yield, economic growth, and soil quality in a temperate farmland. PeerJ, 8. https://doi.org/10.7717/PEERJ.9668/SUPP-1
6. Cheng, J., Ding, C., Li, X., Zhang, T., & Wang, X. (2016). Soil quality evaluation for navel orange production systems in central subtropical China. Soil and Tillage Research, 155, 225–232. https://doi.org/10.1016/J.STILL.2015.08.015
7. Clark, C. M., & Tilman, D. (2008). Loss of plant species after chronic low-level

nitrogen deposition to prairie grasslands. Nature, 451(7179), 712–715. https://doi.org/10.1038/NATURE06503
8. Ding, X., & Han, X. (2014). Effects of long-term fertilization on contents and distribution of microbial residues within aggregate structures of a clay soil. Biology and Fertility of Soils, 50(3), 549–554. https://doi.org/10.1007/S00374-013-0867-6
9. Dr. BalasahebChakor, Mp. (n.d.). . Role of Kushiseva Kendra in Agriculture Development . Yashwantrao Chavan Maharashtra Open University, Nashik.
10. Dr. Govind Kashinath Zende. (n.d.). Nature Farming New Vision . Sun Publication, Pune.
11. Dr. Jaywantrao Patil. (n.d.). Progress of Agricultural Development in India. Krishi Granth Bhandar Publications, Pune.
12. Ekblad, A., & Nordgren, A. (2002). Is growth of soil microorganisms in boreal forests limited by carbon or nitrogen availability? Plant and Soil, 242(1), 115–122. https://doi.org/10.1023/A:1019698108838
13. Elliott, E. T. (1986). Aggregate Structure and Carbon, Nitrogen, and Phosphorus in Native and Cultivated Soils. Soil Science Society of America Journal, 50(3), 627–633. https://doi.org/10.2136/SSSAJ1986.03615995005000030017X
14. Fierer, N., Schimel, J. P., & Holden, P. A. (2003). Variations in microbial community composition through two soil depth profiles. Soil Biology and Biochemistry, 35(1), 167–176. https://doi.org/10.1016/S0038-0717(02)00251-1
15. García-Orenes, F., Roldán, A., Mataix-Solera, J., Cerdà, A., Campoy, M., Arcenegui, V., & Caravaca, F. (2012). Soil structural stability and erosion rates influenced by agricultural management practices in a semi-arid Mediterranean agro-ecosystem. Soil Use and Management, 28(4), 571–579. https://doi.org/10.1111/J.1475-2743.2012.00451.X
16. Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fließbach, A., Buchmann, N., Mäder, P., Stolze, M., Smith, P., El-Hage Scialabba, N., & Niggli, U. (2013). Reply to Leifeld et al.: Enhanced top soil carbon stocks under organic farming is not equated with climate change mitigation. Proceedings of the National Academy of Sciences of the United States of America, 110(11). https://doi.org/10.1073/PNAS.1221886110
17. Gerliani, N., Hammami, R., & Aïder, M. (2019). Assessment of the extractability of protein-carbohydrate concentrate from soybean meal under acidic and alkaline conditions. Food Bioscience, 28, 116–124. https://doi.org/10.1016/J.FBIO.2019.01.004
18. Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. Science, 327(5967), 812–818. https://doi.org/10.1126/SCIENCE.1185383

19. Guo, L., Wu, G., Li, Y., Li, C., Liu, W., Meng, J., Liu, H., Yu, X., & Jiang, G. (2016). Effects of cattle manure compost combined with chemical fertilizer on topsoil organic matter, bulk density and earthworm activity in a wheat-maize rotation system in Eastern China. Soil and Tillage Research, 156, 140–147. https://doi.org/10.1016/J.STILL.2015.10.010
20. Hill, J. O., Simpson, R. J., Ryan, M. H., & Chapman, D. F. (2010). Root hair morphology and mycorrhizal colonisation of pasture species in response to phosphorus and nitrogen nutrition. Crop and Pasture Science, 61(2), 122–131. https://doi.org/10.1071/CP09217
21. Joergensen, R. G., & Wichern, F. (2008). Quantitative assessment of the fungal contribution to microbial tissue in soil. Soil Biology and Biochemistry, 40(12), 2977–2991. https://doi.org/10.1016/J.SOILBIO.2008.08.017. Kaur, K., Kapoor, K. K., & Gupta, A. P. (2005). Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. Journal of Plant Nutrition and Soil Science, 168(1), 117–122. https://doi.org/10.1002/JPLN.200421442
22. Koch, H. J., & Stockfisch, N. (2006). Loss of soil organic matter upon ploughing under a loess soil after several years of conservation tillage. Soil and Tillage Research, 86(1), 73–83. https://doi.org/10.1016/J.STILL.2005.02.029
23. Liu, Z. jun, Zhou, W., Shen, J. bo, Li, S. tian, Liang, G. qing, Wang, X. bin, Sun, J. wen, & Ai, C. (2014). Soil Quality Assessment of Acid Sulfate Paddy Soils with Different Productivities in Guangdong Province, China. Journal of Integrative Agriculture, 13(1), 177–186. https://doi.org/10.1016/S2095-3119(13)60594-8
24. McGill, B. (2015). Land use matters. Nature, 520(7545), 38–39. https://doi.org/10.1038/520038A
25. Nabiollahi, K., Taghizadeh-Mehrjardi, R., Kerry, R., & Moradian, S. (2017). Assessment of soil quality indices for salt-affected agricultural land in Kurdistan Province, Iran. Ecological Indicators, 83, 482–494. https://doi.org/10.1016/J.ECOLIND.2017.08.001
26. Oehl, F., Sieverding, E., Mäder, P., Dubois, D., Ineichen, K., Boller, T., & Wiemken, A. (2004). Impact of long-term conventional and organic farming on the diversity of arbuscular mycorrhizal fungi. Oecologia, 138(4), 574–583. https://doi.org/10.1007/S00442-003-1458-2
27. Olsson, P. A. (1999). Signature fatty acids provide tools for determination of the distribution and interactions of mycorrhizal fungi in soil. FEMS Microbiology Ecology, 29(4), 303–310. https://doi.org/10.1016/S0168-6496(99)00021-5Ponisio, L. C., M'gonigle, L. K., Mace, K. C., Palomino, J., Valpine, P. De, & Kremen, C. (2015). Diversification practices reduce organic to conventional yield gap. Proceedings of the Royal Society B: Biological Sciences, 282(1799).

https://doi.org/10.1098/RSPB.2014.1396
28. Wagg, C., Jansa, J., Stadler, M., Schmid, B., & Van Der Heijden, M. G. A. (2011). Mycorrhizal fungal identity and diversity relaxes plant-plant competition. *Ecology*, *92*(6), 1303–1313. https://doi.org/10.1890/10-1915.1
29. Watanabe, F. S., & Olsen, S. R. (1965). Test of an Ascorbic Acid Method for Determining Phosphorus in Water and NaHCO 3 Extracts from Soil . *Soil Science Society of America Journal*, *29*(6), 677–678. https://doi.org/10.2136/SSSAJ1965.03615995002900060025X
30. Yang, Y., He, Y., & Li, Z. (2020). Social capital and the use of organic fertilizer: an empirical analysis of Hubei Province in China. *Environmental Science and Pollution Research*, *27*(13), 15211–15222. https://doi.org/10.1007/S11356-020-07973-4
31. Yang, Z. C., Zhao, N., Huang, F., & Lv, Y. Z. (2015). Long-term effects of different organic and inorganic fertilizer treatments on soil organic carbon sequestration and crop yields on the North China Plain. *Soil and Tillage Research*, *146*(PA), 47–52. https://doi.org/10.1016/J.STILL.2014.06.011
32. Yu, H., Ding, W., Luo, J., Geng, R., & Cai, Z. (2012). Long-term application of organic manure and mineral fertilizers on aggregation and aggregate-associated carbon in a sandy loam soil. *Soil and Tillage Research*, *124*, 170–177. https://doi.org/10.1016/J.STILL.2012.06.011
33. Zhang, X., Xin, X., Zhu, A., Yang, W., Zhang, J., Ding, S., Mu, L., & Shao, L. (2018). Linking macroaggregation to soil microbial community and organic carbon accumulation under different tillage and residue managements. *Soil and Tillage Research*, *178*, 99–107. https://doi.org/10.1016/J.STILL.2017.12.020
34. Zhou, Z., Zhang, S., Jiang, N., Xiu, W., Zhao, J., & Yang, D. (2022). Effects of organic fertilizer incorporation practices on crops yield, soil quality, and soil fauna feeding activity in the wheat-maize rotation system. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/FENVS.2022.1058071

Tribal Population Density in the Akole Tehsil, Ahmednagar District, Maharashtra State

Pramila Popatrav Zaware
Ph.D. Research Scholar in Geography, Ankushrav Tope College, Jalana, Maharashtra, India
Email- vasusalunke@yahoo.co.in
Vasudev Salunke
Associate Professor in Geography, K.J.Somaiya College Kopargaon, Maharashtra, India
Email- vasu1984salunke@gmail.com
Tukaram D. Gajar
Assistant Professor in Geography, Ankushrav Tope College, Jalana, Maharashtra, India
Email- tdgajar@gmail.com

Article DOI Link: https://zenodo.org/records/10559201
DOI: 10.5281/zenodo.10559201

Abstract:

Population density is the ratio of the total area to the total living population in the same area. From this one can understand the pressure of population on the land or area. In short, it is index that show how much people depend on the land resource. In tribal area like Akole taluka tribal population is increasing with slow pace. It has jumped from 80per sq.Km in2001 to 92 per sq.Km in 2011 Census. It is shows how agricultural sector is pressurized by population. The higher the value of population density, the greater the population pressure on surrounding resources like agricultural land, water, electricity, roads etc. In contrast, the lower the density of population, the lower the population pressure on the above said resources. For this study, population data between 2001 and 2011 have been taken. In addition, secondary data has been used for this study.

Keywords: Population density, Land Man Ratio, Population Pressure, Human Resource, Tribal Population

Introduction:

Population dynamics in any region deals with quantitative and qualitative aspects of population and their consequences on the socio-economic environment. The physical attributes of an area become resources, only when its people are able to use them. Population plays a dominant role in the development of nation.The population of any country or region is an asset depending on the quality of the population and the numerical factors. Shejul Meena (2021) The relationship between population and resources is greatly hampered by socio-economic development of a nation. The term population density was first used by Henry in 1837 for preparation of railway maps. Population density helps us to understanding nature of population distribution. Which is

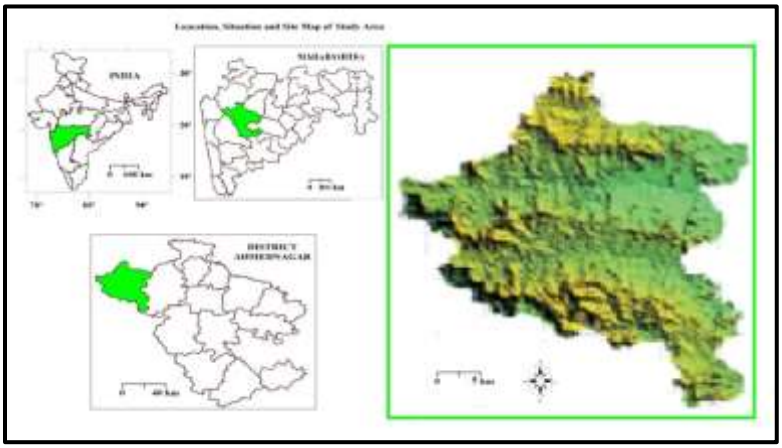
becomes one of the main issues in the national as well as international, mainly because of natural resources and population growth in the post-independent period. Some time population density remains important in spreading epidemics in high population density ,such as big or metro cities have higher probability of infection of diseases.

With increasing Population it reached to an explosive stage where population pressure is highest and it release through migration hence migration is an important outlet of overpopulation. In this study population density of Akole tehsil (2001 to2011) has been analyzed to assess Land man Ratio to calculate pressure of Population. The use of remote sensing and GIS methods is leading to a large collection of demographic information. The people's knowledge and skill education attainment are the importance human resources which are closely associated with population density. The economic activities, agriculture associated activities, agricultural development are affected with changing population density.

Study Area:

Geographically Ahmednagar district is the largest district in the state of Maharashtra, divided into 14 Tehsil. One of the Akole Tehsil which is on the western Hilly region of Ahmednagar district, it is divided into 191 villages. Surrounded by Sangamner tehsil from East side, to the West side Thane district, to the North side Nashik district and in to the South direction Pune district. Well surrounded with the mountains range of Sahyadri in Western side. Akole Tehsil is located in 190 15' 14" N to 190 44' 59" N latitude and 730 37' 00"to 740 07' 24" E longitudes (Map. No 2.1). Total Geographical area is 1, 49,990.31 hector (1499sq.K.M). Total population of this Tehsil is, 2,77, 171 in 2011 Census year, out of 1, 01,966 (ST) Tribal population is in this study area.

Map No. 1: Geographical Location



ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Aims and Objective: The basic aim of this study is to find out, spatio-temporal analysis of Tribal population density of Akole tehsil between 2001 to 2011 census at micro level.

Methodology:

The present study depends on only secondary data sources about Indian population census in 2001 to 2011. Population data of Akole Tehsil from 2001 to 2011 census years. The used statistical formula for Population density, it means ratio between populations and area multiple 100. Density is population as the number of persons per square Km. Researcher used the following formula to calculate population Density of Area. .

$$\text{Population Density} = \frac{\text{Population of Taluka}}{\text{Area of Taluka in Sq.Km}}$$

Result and Analysis:

Density of non- tribal and tribal population has quite a few differences in many ways. Tribal villages and non tribal villages show noteworthy difference in density Therefore tribal density were measured to study distributional pattern of tribal population and their concentration in Akole tehsil. Even though total density of Akole tehsil was 176 person per sq. Km and 193 person per sq. Km in 2001 and 2011 respectively.

A) Tribal Population Density in 2001 Census:

Tribal Population density according to 2001 data was recorded 80 person per square Km. Tribal density was categorized in five sub groups in ascending order in that very low, low, medium, high very high groups are included. In this classification 54 villages were sort out in first very low tribal density group in which density was observed below 24 people per sq.km. In next class low density group 42 villages were included in these villages tribal density was between 25 to 69 person per sq. Km.

In next medium density group 48 villages were included in these villages 48 villages were categorized and density in these villages were observed between 70 to 141 persons per sq. Km .In high density group 38 villages were included and density in these villages ranges between 142 to 278 person per sq. Km. In last very high density group very few, only 5 villages were categorized in these villages population density were observed between 279 to 507 person per sq. Km.

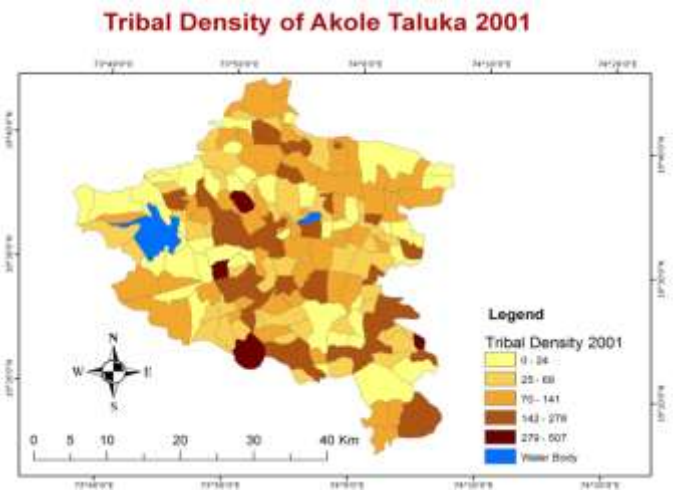
B) Tribal Population Density in 2011 Census:

Tribal Population density according to 2011 data was recorded 92 person per square Km. In case of 2011 data 74 villages were include in very low density group density in these villages were below 47 person per sq. Km. In low density group 46 villages were included where density is ranges between 48 to 111 persons per sq. Km. In medium density group 42 villages were categorized where density is ranges

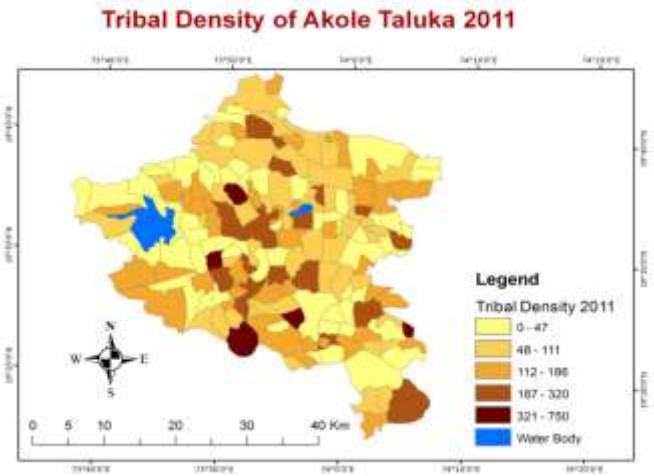
Between 112 to 186 people per sq. Km. In high density group 22 villages were included in these villages density observed ranges from 187 to 320. In last very high

density group only five villages were included in which population density was above 321 person per sq. Km.

Map.No.1.1

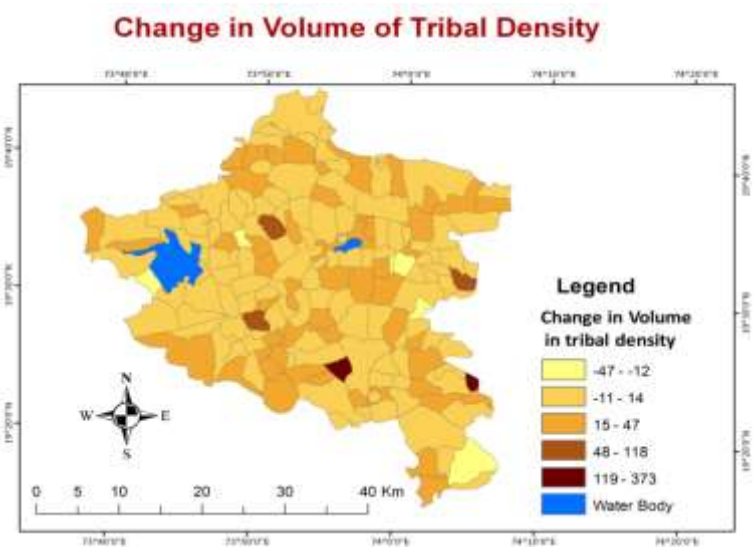


Map.No.1.2



Volume of change between 2001 to2011 was detected in Fig.No.1.3. It has been observed that volume of change was classified in to three major categories, low, medium and high.

Map.No.1.3



Low volume of change was found in 36 villages where change is in negative form. This change ranges from - 47 to -1. In medium volume of change in 149 villages of Akole tehsil were scrutinized. In this group change ranges from 0 to 50 persons per sq. Km. In the last group where tribal density was found more than 50 people per sq. Km. In the only 6 villages were seen.

Conclusion:

Population Density of tribal region of Akole tehsil is highly fluctuating very small changes in population density were observed in many villages. Tribal folk is engaged in several primary activities like primary farming, animal grazing fishing, forest product collection etc. Which need natural environment like Forest riversides lakes etc. This favorable environment is easily available in Akole tehsil.

But still some places like Rajur, Bramhanwada and Kotul Shows high change in Population Density because of big market Places and accessibility to road network population density becomes so high and changes.

References:

1. Ahmednagar District Gazetteer
2. Arunava Bhadra (2021) 'Impact of population density on Covid-19 infected and mortality rate in India' Model Earth Syst 2021,7(1) ,623-629 doi: 10.1007/s40808-020-00984-7
2. Census of India2011:Provisional Population Totals India, Series1
3. CholkeS.P.(2011):Decadal variation in Population growth of Ahmednagar District. XXXVI Maharashtra Bhugolshastra Patrika pp 33-38
4. District Census Handbook Of Ahmednagar District-1951-2001

5. Husain Majid(2009):Models in Geography pp 144-146
6. Khullar D.R.(2007):India A comprehensive Geography pp391-396
7. Korade S.M.(2008):A Spatio temporal study of Ahmednagar district BCUD project pp-25-28.
8.Vasudev Salunke (2018) "Levels of Human Resource Development in Ahmednagar District of Maharashtra." International Journal Vidyawartha pp26.
9. Vasudev Salunke (2018) "A Study of Population Density in Ahmednagar District of Maharashtra State." Electronic Interdisciplinary International Journal ,pp345.
10.Shejul Meena(2021)'Geographical Study of Population Characteristics in Ahmednagar District, Maharashtra State, India' Int. J. Sci. Res. in Multidisciplinary Studies Vol.7, Issue.3, Mar 2021

A Critical Study On The Problem Of Spreading Waterborne Diseases Related To Dissolving Chemicals And Its Effect In Vichumbe Village.

Raviprakash D. Thombre
Department of Geography & Geoinformatics, Rayat Shikshan Sanstha's, Karmaveer Bhaurao Patil College (Empowered Autonomous) Vashi, Navi Mumbai, Maharashtra, India
Email- raviprakash3181@gmail.com

Article DOI Link: https://zenodo.org/records/10559207
DOI: 10.5281/zenodo.10559207

Abstract:

The earth is the only planet in the solar system where we are able to discover water. The world's primary commodity for existence is water. Access to pure drinking water has historically been one of the cornerstones of superb public health. Polluted water can also be an indicator of illnesses transmitted by water; consequently, safe water is not just limited to drinking water. The treatment of water is needed due to the value of hygienic and chemical purity in water for human health. Due to the probability that an array of pathogenic microorganisms that because waterborne diseases may be introduced through contact by drinking water. The most significant obligation is to continually evaluate the water supply system's drinking water quality. The current study looks on the poor quality of tanker water that arrives to several populations in Vichumbe Village during the summer, rainy season, and winter. In this study, the level of ph., temperature, viscosity, hardness, alkaline levels, chlorides, fluorides, nitrate, iron, and silica in water samples are among the various physio- chemical characteristics as that are evaluated. This water specimen will show that the spread of waterborne illnesses such diarrhea because typhoid fever, and dysentery can be triggered by poor water quality.

Keywords: Infectious Agent, Water Utility, Waterborne Disease

Introduction:

Water is one of the most important things which is required for life and in the universe the earth is only planet which is having water. Water means the clear liquid, without color and taste, which falls from the sky as rain and it is necessary for animals and plant life. Waterborne means which is carried or transmitted by water and especially by drinking water. Waterborne illness is because of disease-causing microbes or pathogens. Many developing countries do not have proper water treatment plants, especially in rural areas. In some places because of less water resources people have neither the money nor the time to afford purifiers or other water treatment mechanisms. These waterborne diseases affect mainly the children and other people due to poor hygiene and weak immunity.

a report by the World Health Organization, 159 million people depend on surface water. An essential source of drinking water is not accessible to nearly 844 million individuals. Protozoa, bacteria, intestinal parasites, and other microorganisms that penetrate the human system through the digestive tract walls can all cause disorders that are passed on by water. Whether bathing, washing, drinking water, or eating food that was brought into contact with contamination, illnesses transmitted by water can spread. Viruses are responsible for the spread of a variety of aquatic infections. Other various waterborne diseases are spreading because of viruses. Minimal daily water we need its range between 1 to 3L per person per day for hydration, perhaps as little as 2-3L for food preparation, 6-7L for personal hygiene, and 4-6L for laundry. According to UNICEF (2015), just 660 million people, or 9% of the population of the globe, do not have access to "improved" sources of drinking water. In 1990, this number was 24%. 90% of child deaths occurred over the past 40 centuries. In it, pneumonia, malaria, newborn illnesses, and dysentery are the main causes of mortality.

Geographical location of vichumbe:

Vichumbe coordinates are as follows:

Longitude: 73.132543 E

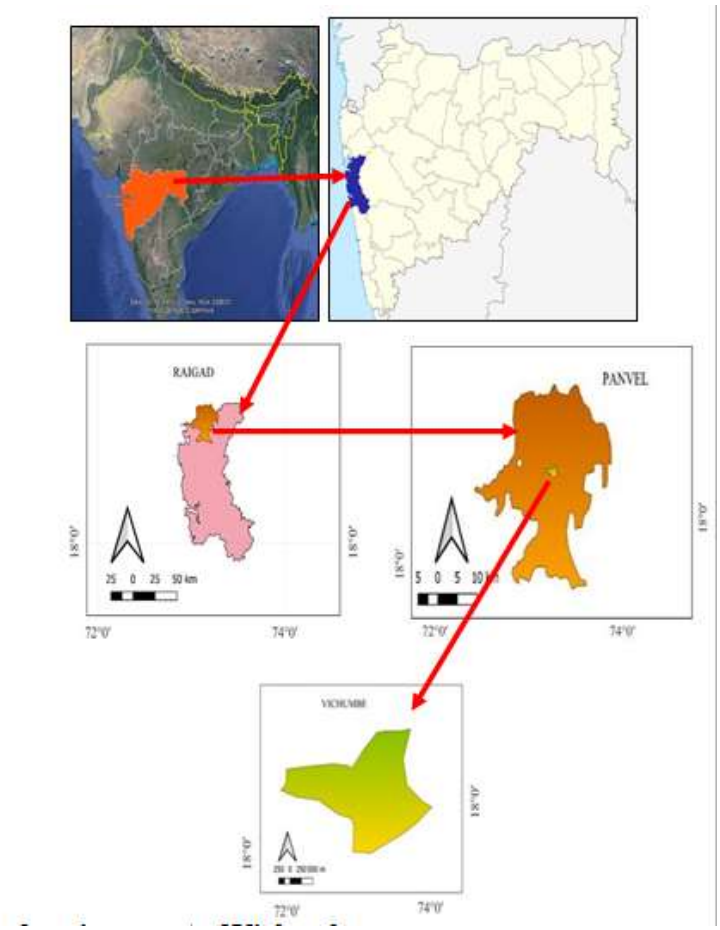
Latitude: 18.987123 N

The GPS position is $18^0$59'N and $73^0$7'E.

Study Area:

Vichumbe is a town in the Panvel Taluka in the Raigad District of the Indian state of Maharashtra. It is located near New Panvel. Vichumbe town is a part of the cidco Smart city NAINA project. There are 6,332 people living there in total.2820 women and 3,512 men make up the remainder of the population. Vichumbe Village has a 76.69% literacy rate, with 80.67% men and 71.74% females being literate. In the neighborhood of Vichumbe, there are around 1624 homes. Vichumbe Gramm Panchayat is the government organization, and Mrs. Namrata Akash Patil is the Sarpanch. Marathi is the official language. It is a part of the Konkan area. There is a probability of humidity in the air because it is close to the Arabian Sea. It is located 5 km from Panvel's district headquarters.(Tahsildar Office) and 69 km from Alibag, the district headquarters. According to data from 2009, Vichumbe village also has a gram panchayat. Latitude 18.98 North and Longitude 73.13 are the geographic boundaries of the region. It covers 119 Hectares of land. A total of 75 hectares are utilized for agriculture, of which 75 hectares are irrigated and 24 hectares are not. It experiences 133.46 wet days (36.56% of the time) and receives around 261.01 millimeters (10.28 inches) of precipitation yearly.

Study Area Map:



India **Maharashtra**

Weather and environment of Vichumbe

Vichumbe endures tropical monsoons. Vichumbe's average temperature ranges from 28 to 35 degrees. The average humidity is 64%, there are a total of 217 dry days each year, and the UV index is 7. The indicator reads 1011 megabytes. About 49% humidity is deemed to be very humid.

Water scarcity in Vichumbe:

The primary reason is Cidco's sewage water, which has been polluting the nearby Gadhi river and creating the worst state of water resources. In particular areas, the water does not reach all the way to the end during the summer due to low levels of water and low water pressure, and it could require more machinery to generate sufficient

force there. In the meanwhile, depending on tankers carrying water to make up for the
In the meanwhile, depending on tankers carrying water to make up for the water supply deficit is hurting family units due to the costly prices they ask.

Tap water supply

Tanker water supply in study area

Statement of problem:

The most crucial component for life is water. We should drink enough water each day for good health. Good Dehydration may affect your ability to think clearly, cause your body to overheat, and result in constipation and kidney stones. Dehydration can be prevented by drinking water. It is being noted that the majority of tankers delivering water to people get their water from drainage systems; this water may be harmful to your health and in some instances may even cause serious medical conditions. My research focuses on the tanker water and how it affectsthe health of the Vichumbe village residents.

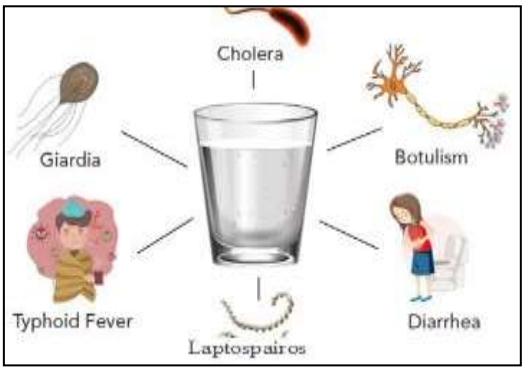
Origin of Research Problem:

Vichumbe village is located in Panvel tahsil of Raigarh district in Maharashtra, India. It is situated 5km away from sub-district headquarter Panvel (tehsildar office) and 69km away from district headquarter Alibag. As per 2009 stats, Vichumbe village is also a gram panchayat.

The total geographical area of village is 119 hectares. Vichumbe has a total population of 6,332 peoples, out of which male population is 3,512 while female population is 2,820. Literacy rate of Vichumbe village is 76.69% out of which 80.67% males and 71.74% females are literate. There are about 1,624 houses in Vichumbe village. Whether water is utilized for drinking, household usage, food production, or recreationalactivities.

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

This service is particularly critical in healthcare institutions where a lack of sufficient water, sanitation, and hygiene services exposes both patients and employees at danger of infection andsickness. There is a water shortage in the area where I live. There



is no municipal corporation water in Vichumbe village. Consequently, many rely on tankers and ground water. It was noticed that both our society and the other societies in Vichumbe village had a high sickness rate. In such locations, cholera, diarrhea, dysentery, hepatitis A, and typhoid are prominent diseases. After the doctor had examined you, drinking heated water was suggested. Therefore, I have determined that the effects of dissolved chemicals in drinking water on the residents of Vichumbe Village should be the subject of my investigation.

Water Borne Diseases

Imporatnce Of Research:

The health of people is seriously threatened by poor water quality. Every year, 2 million individuals lost their lives due to diarrheal illness alone. According to estimates, 88% of theload falls mostly on children in countries that are developing and is attributed to hazardous water supply, sanitation, and hygiene. My study is crucial for preventing the spread of this sickness. Numerous lives can be saved through supplying more people with access to clean drinking water, appropriate sanitary facilities, and better hygiene practices.

Objectives:

1. To analyze the supply of drinking water
2. To Assement of Water Quality
3. To find out the Health Impact Assesment.

Methodology:

This study aims to study the impact of impure water in Vichumbe village, to study the supplyof water in study area. For studying this impact, we are collecting data from various primary and secondary sources. For analyzing the impact of impure water and fault in function of supply I collect data using Questionnaire in form of Google

forms. Interviews with the village people, tanker suppliers andresource water owner.

Assumptions: -

1. Assumptions are those things, which is possible or accepted as true by researcher andpeers who will read the dissertation.
2. It applies only on the people of Vichumbe Village
3. Those people will use only Tanker water for drinking and other purposes.
4. Those people are getting sick frequently.
5. This is the study of finding impact of tanker water.
   Assumptions are those things, which is possible or accepted as true by Researcher and peers who will read your dissertation.

Limitations:

1. This research is based on the citizen of Vichumbe village only
2. This research is analyzing tanker water‘s quality.
3. This research will analyze the waterborne disease only.

Hypothesis: There is no significant relationship between the presences of dissolved chemicals in water Sources and the incidence of waterborne diseases in Vichumbe Village. The presence of dissolved chemicals in water sources is significantly associated with an Increased incidence of waterborne diseases in Vichumbe Village.

Review of Literature:

R. D. Arnone and J. P. Walling described that combined sewer systems (CSSs) that transport a combination of pathogen-filled rainwater and sanitary wastewater through a single pipe to a publicly operated treatment plant for treatment before release to surface waterways. According to the USEPA, CSSs are prevalent in older communities in the Northeast and Great Lakes areas and may be identified in 32 states (including the District of Columbia). When capacity is surpassed during times when there is moderate to severe rainfall, combined sewer overflows (CSOs) happen

I. R. Joh, H. Wang, H. Weiss, and J. S. Weitz, suggested we discover an additional control parameter, which we call the pathogen enhancement ratio, which controls whether outbreaks result in epidemics or endemic disease states. It is related to the shedding rate of infected people. According to our model, reducing the number of affected people may be less successful than decreasing the pathogen density in aquatic reservoirs in the case of waterborne infections.

A. Shannon, W. Bohn, M. Elimelech, G. Georgiadis, J. Marinas, and M. Mayes told Here, we showcase some of the research and technology currently being investigated for improved water disinfection and decontamination, as well as measures to boost water supplies through safe wastewater re-use and effective desalination of sea and brackish water.

S. Batterman, J. EIsenberg, R. Hardin et al.describethat In particular, we argue that

one problem with interventions to reduce infectious disease incidence and emergence, particularly those that are water-associated, is that efforts are generally directed against proximal causes of infection transmission, paying less (and often insufficient) attention to the more distal causal factors. These issues represent major gaps that cannot be resolved by simply boosting funding for water supply and sanitation facilities.

Kaustubh Karande explained that for a well managed water supply, it's essential to manage the waste that is generated wastewater in addition to the infrastructure. This research illustrates the lack of wastewater treatment plants before disposal in the majority of the Communities

Shailendar Kumar Maryada and others publishers described because there are not sufficient resources allocated in India to clean up lakes. All of this is as a consequence of the lack of a lake cleanup strategy by the government or any other organization. The possibility of illness spreading, which is already present in the world around us, is imminent. which, like the Corona virus, none of us are aware.

Water Resource Status In Vichumbe In 2023:

Panvel, an Indian city, receives water from the Dehrang Dam, which is predicted to dry out by the first week of June. The predicament is becoming worse in VICHUMBE. There is a lot of growth going on, which causes the population to grow, which raises the need for water.

In the Indian state of Maharashtra, the Morbe Dam is a gravity-based structure on the Dhavari River close to the town of Khalapur. The city of Navi Mumbai gets its water mostly from More Lake. It was constructed by the Maharashtra government's water supply and sanitation department.

During the Monsoon the Gadeshwar dam overflows. The place can be reached by entering NewPanvel and via the Sukhapur-Nere road.

Table: 3.1 The Precipitation and Temperature in Vichumbe:

Category	**Resolution**	**Period**
Precipitation	Half Hourly/0.1 deg (11 kms) grid	2001-2023
Precipitation	Daily/ 0.25 deg(28 kms) grid	1901-2023
Temperature	Monthly/ 0.5 deg (55 kms) grid	1901-2022
Temperature	Daily/1 deg (111 kms) grid	1951-2023

Total area of Vichumbe is 119 Hectares as per the data available for the year 2009Total sown /agricultural area is 75 Hectares. About 75 Hectares is irrigated area. About 24 hectares is in non agricultural use. About 20 hectares is culturable waste land.

Table No 3.2

Sr. No	**Category**	**Hectare**
1	Total sown/agricultural area	75 hectares
2	Non-agricultural use	24 hectares

3	Culturable waste	20 hectares
4	Total Area in Vichumbe	119 Hectare

Figure No 3.2

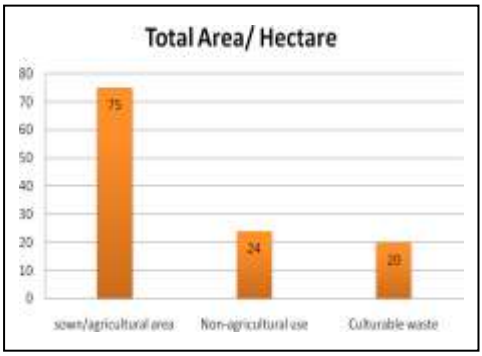


Table: 3.3

While collecting data it was received the information that is most important for this study. In it we can see there is 31.7% Tanker water is used, 36.6 % people use boring water.26.8% lake water is used for drinking. 5% People use well for drinking purposes.

Sr. no.	Water Resources	Used %
1	Boring	36.6
2	Tanker	31.7
3	Well	5
4	Lake	26.8

Table 3.3

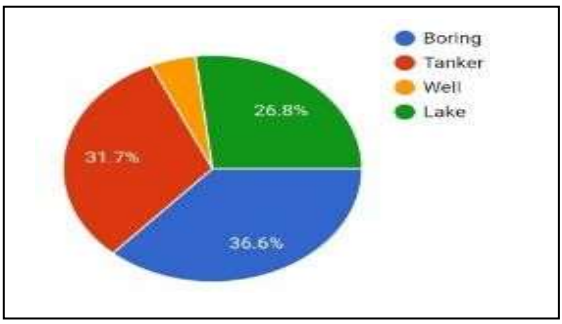


Figure No 3.3

Table 3.4

The water is infected then the people of that area will be sick. 48.8% of the peoplesay that water is safe for drinking; other 30% of people say that water is not safe and 22.5% of people say that they have no idea whether it is safe or unsafe.

Table3.4

Sr. No	Quality of Water	Suggestion percentage
1	Safe Water	48.8
2	Not Safe	29.2
3	No Idea	22

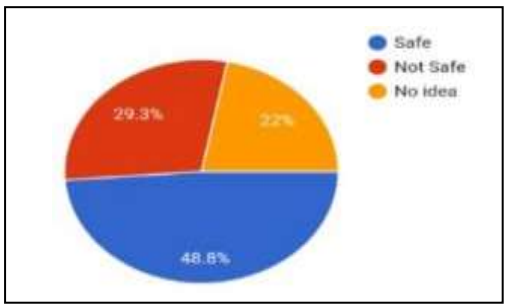


Figure No 3.4

Table 3.5

For assessing the quality of water some people use the cloth to remove the dirt, some people use bleach, some use the water filter. During the questionnaire it was asked that whether they use the water filter or not. But the village Vichumbe some people cannot afford the w and the other after filter so sometimes because of impure water they get sick. 97.5% Residents use water filter and other 2.5% family do not use water filter.

Table 3.5

Sr.no.	Source for cleaning	Source %
1	Water Filter	97.5
2	Other	2.5

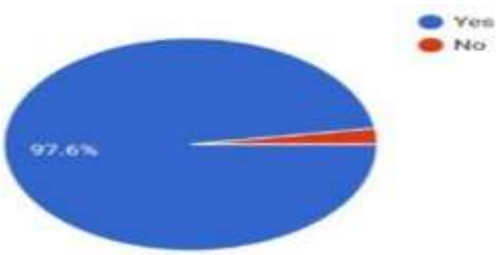


Figure No 3.5

Table 3.6

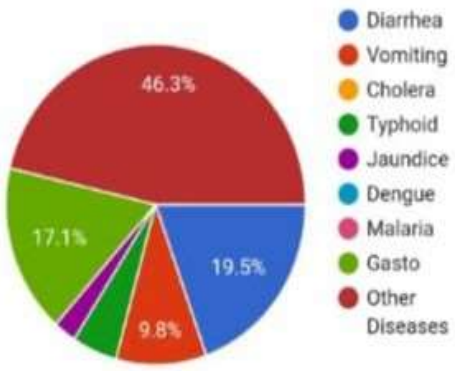
Water is the most important factor of life. The pure water is the boon for healthy life, but the impure water could be the cause of so many diseases. Like Diarrhea,

Vomiting, Cholera, Typhoid, Jaundice, Dengue, Malaria, Gastro, Other diseases. In other diseases like dysentery, loose motions, stomach ache. Here we can see 45% of the people are suffering from other diseases, 20% suffered from Diarrhea, 10% experiencing Vomiting, 17.5% feeling Gastro, 5.5% Typhoid and 2% experiencing Jaundice

Table 3.6

Sr. no	Suffering Diseases	% of disease
1	Diarrhea	10
2	Vomiting	17.5
3	Cholera	0
4	Typhoid	2
5	Jaundice	2
6	Dengue	0
7	Malaria	0
8	Gastro	5.5
9	Other Disease	20%

Figure No 3.6



During survey it was observed that while getting sick, the people take different types of medicines, like Allopathy, Homeopathy, Ayurveda, Domestic or self-medicines and other. While getting sick 42.5% people of Vichumbe use Allopathy or the English Medicine. 10% use Homeopathy, 20% use Ayurvedic, 17.5 % use domestic or self medicine and 10% use other medicines.

Table 3.7

Sr. No.	Types of Medicines	% of medicines
1	Allopathy	41.5
2	Homeopathy	9.8
3	Ayurvedic	19.5
4	Domestic	17.1
5	Other	12.2

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

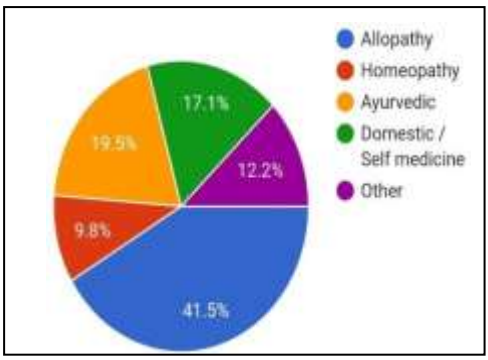


Figure No 3.7

Table 3.8

Due to impure water the waterborne diseases get active. Frequently use of infected water makes the people sick. In the Area 23% were sick because of dysentery and 10% by stomach ache and 5% suffered from Gastro.

Table 3.8

Sr. no	Type of waterbornediseases	% of disease
1	Dysentery	23
2	Stomach ache	10
3	Gastro	5
4	No illness	62

Figure No 3.8

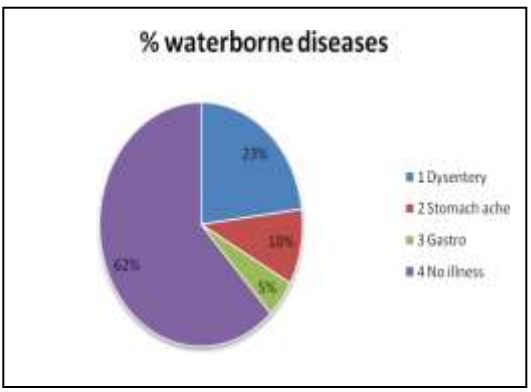


Table 3.9

If the water is spreading diseases, then it is important to make it clean. 73% people use a waterfilter, 10 % use chlorine and 5% boil to clean it. These are common methods to clean the water.

Table 3.9

Sr.no	Methods of cleaning	% of cleaning
1	Water filter	73
2	Added bleach/chlorine	10
3	Boiling	9
4	Using cloth	5
5	Other	3

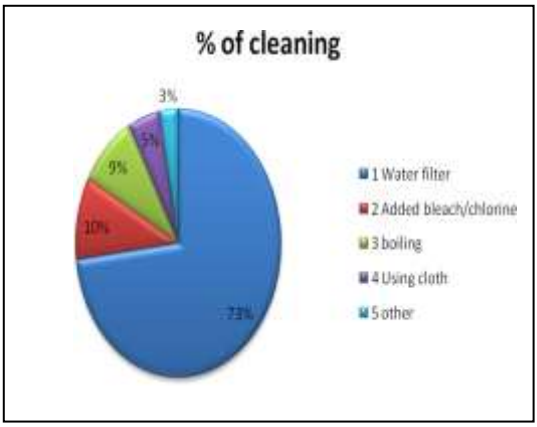


Figure No 3.9

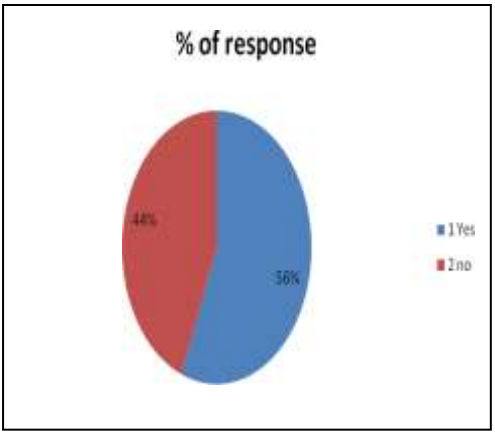
Table 3.10

Clean water is the most important requirement of the public. Definitely the government should take the action for it but the public initiative is very important thing.56.1% people complainedto the concerned authority and 43.9% people do not care about it

Table 3.10

Sr. no	Complained theauthority	% of response
1	Yes	56.1
2	No	43.9

Figure No 3.10



Samples Analysis:

Three samples from the Centre for Research, Consulting, and Technical Services are evaluated as part of this study in the lab at KBP College. The first sample is tap water, as shown by the certificate of analysis. The pH level as of right now is 7.93.As we can see, the pH of regular bottled water should be between 6.5 and 7.5, but the sample of tap water has greater pH than is typical. Because it is closest to 8, the pH level in the test indicates that it is unfit for drinking. The pH range of ocean water is 8 to 8.1.

Sample 1: Tap water

Water that comes from a public water system and is delivered by pipes or other built-in conveyances is referred to as "tap water."

Ph level in Tap water:

Tap water's ph varies greatly depending on its sources, processing, and distribution methods. As a result, tap water's pH will vary. Is tap water safe to drink if the pH level is outside of defined ranges. The organizations acknowledge that there is no specific health rationale for this range, yet continued use of this water can be harmful to health. There are not so many cases where the pH level alone caused tap water to be unsafe.The suggested pH range of 6.5 to 9.5 for tap water does, however, take into account the fact that most systems seek to keep their pH levels above 7 to reduce the impacts of corrosion in their treatment facilities and pipe distribution network.

TDS Level in water

Today, the water treatment facilities discharge dangerous substances into the drinking water that we get. As a consequence, the water's inherent minerals are removed. The correct filtering method must be used in this circumstance to get rid of the impurities and make the water safe todrink. Total dissolved solids (TDS), which are still in water after the usual filtering procedure, are the principal pollutants that are present. Total dissolved solids are contaminants that are greater than 2 microns.

Sample-2 - Boring water:

It is found that pH level is 7.87, after sample test of boring water. Actually bore water comes from groundwater which in turn comes from rain that has naturally seeped into the ground and is stored in spaces between soil and rocks. From the result it is evident that the pH is well within permissible limit pH (6.5 to 8.5) has no direct adverse effects on health, however a lower value below 4 will produce sour taste and higher value above 8.5 bitter taste.

Sample 3 – Tanker Water:

Private water tankers have become more prominent in the water delivery supply chain which makes it especially challenging to ensure water quality and prevent the spread of waterborne illness.

Comparison of Resource water, Tanker water and Tap water

Cities around the globe have been and continue to grow at a rapid pace, fueled by population growth and migration from rural areas. In many cases, water-provision infrastructure in the form of piped networks fails to keep up with the pace of urbanization and increasing demands for water quantities, e.g., resulting in unconnected areas, intermittent supply, and water-quality issues.

Measurement of pH:

The pH is important parameter of water, which determines the suitability of water for various purposes such as drinking, bathing, cooking, washing and agriculture etc. The pH level of water having desirable limit is 6.5 to 8.5 as specified by the BIS. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered as basic or alkaline.

Table No 3.11 Comparing the values of the samples, I received the analysis of all three samples.

Conclusion, Future Scope and Recommendation

Conclusion:

The conclusion drawn from the statement suggests a correlation between the presence of dissolved chemicals in water sources and an elevated occurrence of waterborne diseases in Vichumbe Village. If this correlation is based on empirical evidence and scientific studies, it highlights a critical issue that demands attention and intervention. The implications of such a connection may include:

1 .**Health Risks**: The increased incidence of waterborne diseases implies a potential threat to the health of the community in Vichumbe Village. Waterborne diseases are often caused by pathogens present in contaminated water, and the role of dissolved chemicals in facilitating the growth and spread of these pathogens should be addresse

2 **Water Quality monitoring**: The conclusion emphasizes the importance of regularly monitoring the quality of water sources in Vichumbe Village. Understanding the specific dissolved chemicals present and their concentrations can help identify sources of

contamination and guide remediation efforts

3. **Public Health Intervention**: Given the association with waterborne diseases, public health interventions may be necessary to reduce the impact on the community. These interventions could include water treatment, education on safe water practices, and the promotion of hygiene to prevent the spread of waterborne diseases.

4**. Environmental Impact Assessment:** Understanding the sources of dissolved chemicals in water requires a comprehensive environmental impact assessment. This involves identifying potential sources of pollution, such as industrial discharges, agricultural runoff, or improper waste disposal, and implementing measures to mitigate these sources.

5. **Collaboration and Advocacy**: Addressing water quality issues often requires collaboration between local communities, government authorities, and environmental organizations. Advocacy for policies that regulate and monitor water quality can contribute to long-term solutions.

Future scope:

- Build community partnership

1. Development of community partnership leads to higher attention and support from the general public. Conscious individualities frequently come more involved in decision- making and restoration efforts.
2. Similar involvement builds a sense of community, helps reduces conflicts and increase commitment to the conduct necessary to meet environment pretensions.

Conduct Educational Programs

1. The degree of public education and participation in the planning process can greatly impact the success of awareness of water related issues.
2. There are numerous ways to involve and educate the public in environmental operations, confirmation of citizen review groups and recommendatory panels can gain public support from the milepost.

- **Effective implementation and follow-ups**

1. The water management planning should be enforced in dynamic and adaptive manner.
2. Long –term monitoring of water quality, the expanse provided by the government for Improving water status and their response to perpetration conduct linked in the plan is vital.

Recommendations:

1. Water quility monitoring and testing: Establish a comprehensive water quality monitoring program to regularly test and analyze water samples from various sources in Vichumbe village. Collaborate with relevant health and environmental agencies to ensure the testing process adheres to established standards.

2. Community Health Services: Enhance healthcare facilities in Vichumbe to provide prompt diagnosis and treatment for waterborne diseases. Develop a system for regular health check-ups and medical support for the community to address health issues arising from water contamination.
3. Alternative Water sourcce: Explore and implement alternative water sources such as rainwater harvesting, wells, or safe groundwater to reduce reliance on contaminated water bodies. Introduce filtration and purification systems at the community level to ensure access to clean and safe drinking water.
4. Check and maintain water tanks on a regular basis. Make sure you follow the essential safety precautions, such as alerting someone when you enter and exercising caution while using motorized pumps in confined spaces like asphyxiation tanks

References:

1. R. D. Arnone and J. P. Walling, ‑Waterborne pathogens in urban watersheds,‖ *Journal of Water and Health*, 2007.vol. 5, no. 1, pp. 149–162, View at: Publisher Site | Google Scholar
2. IR. Joh, H. Wang, H. Weiss, and J. S. Weitz, ‑Dynamics of indirectly transmitted infectious diseases with immunological threshold,‖ *Bulletin of Mathematical Biology*, , 2009 vol. 71, no. 4, pp. 845–862,View at: Publisher Site | Google Scholar
3. Shannon, W. Bohn, M. Elimelech, G. Georgiadis, J. Marinas, and M. Mayes, ‑Science and technology for water purification in the coming decades,‖ *Nature*, 2008. vol. 452, no. 7185, pp. 301–310, 2008.View at: Publisher Site | Google Scholar
4. S. Batterman, J. EIsenberg, R. Hardin et al., ‑Sustainable control of water-related infectious diseases: a review and proposal for interdisciplinary health-based systems research,‖ *Environmental Health Perspectives*, 2009 vol. 117, no. 7, pp. 1023–1032,View at: Publisher Site | Google Scholar
5. R. P. Schwarzenbach, T. Egli, T. B. Hofstetter, U. V. Gunten, and B. Wehrli, ‑Global water pollution and human health,‖ *The Annual Review of Environment and Resources*, 2010. vol. 35, pp. 109–136, View at: Publisher Site | Google Scholar
6. S. Rahman, F. Salehin, A. H. M. Jamal, A. Parvin, and K. Alam, ‑Antibacterial activity of argemone mexicana L. against water borne microbes,‖ *Research Journal of Medicinal Plant*, 2011. vol. 5, no. 5, pp. 621–626,
7. View at: Publisher Site | Google Scholar
8. Kaustubh Karande. Journal of Water, Sanitation and Hygiene for Development (2021)
9. **Chidanand Patil, Shreekant Narayanakar and Arjun Virupakshi, ‑**Assessment of Groundwater Quality Around Solid Waste Landfill Area - A Case Study, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue7, July 2013, pp. 3131-3136.)

Urban Expansion and Its Consequence on Landuse Landcover of Fringe Areas of Nagpur City

Jagruti Mahajani
Ph.D Research Scholar, Department of Geography, B.P.H.E. Society's Ahmednagar College, Ahmednagar, Maharashtra, India
Email- jagrutimahajani@gmail.com
Maya G. Unde
Professor and Head, Department of Geography, B.P.H.E. Society's Ahmednagar College, Ahmednagar, Maharashtra, India
Email- maya4unde@gmail.com

Article DOI Link: https://zenodo.org/records/10559220
DOI: 10.5281/zenodo.10559220

Abstract:

Urban growth also called as urban expansion is a major transforming factor of city surroundings. The anthropogenic activities affect the terrain, topography, population, water table and even the climatic conditions of an area. The present study focuses on the implications of urban expansion on Landuse Land Cover (LULC) in and around Nagpur city in central India. Nagpur city is one of the fastest growing cities in terms of development. It is also 13th largest urban municipal corporation in India and has been named as one of the cities in India in 'Smart City Project'. For the study, the three decadal data i.e., from 1990s to 2020s has been taken into account. The paper mainly focused on the study of areas which was incorporated within Nagpur city after 1990. The rise in built-up area, transportation facilities, impact on surrounding agricultural land are the key factors. Different methodologies were adopted like surveying, interviews, statistical analysis and Remote Sensing & Geographic Information System (RS & GIS) techniques were used in collaboration at different stages of data collection, processing, analysis and outcome. The results show the increase in built-up area. During the last 30 years, the growth of the urban built-up is nearly two times than in 1990s. The construction activities have affected important geomorphic features such agricultural land, residual hills and rivulets. It is concluded that the Urban sprawl index has shown a significant growth during the past decade in case of Nagpur city.

Keywords: Urban Growth, Landuse Land Cover, Urban Expansion, Fringe areas.

Introduction:

The major indicator of economic growth of any country is its rate of urbanisation and urban growth in terms of expansion. Cities are growing rapidly in physical dimension in terms of infrastructure, built-up area and population in past few decades.

Historically, there is a large gap in the residential environment construction between the rural and urban areas. But recently, infrastructure surge has speedup the new rural construction and improve the living environment of village resulting into the emergence of urban-rural fringe area (Jin, 2012).

Towns and cities are mostly expanded along the major transportation routes. The other factors that influenced the urbanisation process are the availability of basic civic facilities, water (surface/ground), price of property, and connectivity to the main city area.

Studies have already been carried out over urban expansions with few recognised widely. The urban fringe has been described as 'planning's last frontier'; a zone of transition and interface between town and country where a broad variety of land uses and activities come together, and where development pressure is often intense. The urban fringe possesses special characteristics, making it more than simply a transitional landscape. These characteristics centre on patterns of land use, biodiversity and leisure/development opportunity which are unique to the urban edge and to land extending away from built-up. (Gallent, 2004) The settlement geography is incomplete without taking into consideration the morphology and hydrology of an area. (Ahnert, 1996).

Urban development is one of the substantial factors that shape the quality of human life and its sustainability. However, the intensive growth of housing in the urban fringe seems to threaten this. Meanwhile, the application of spatial design procedures as part of the regulating process has not been successful (Polyzos S., Minetos D., and Niavis S., 2013). A case study of Yogyakarta City focus on the characteristics of housing development, its ecological aspects and its capacity to support the community's capability through field observations and questionnaires. It is indicated that the planned cluster development on the fringe of Yogyakarta City, although supporting the capability of its people, may potentially threaten the ecological balance and long-term macroeconomic situation of the urban area. (Pramono, R. (2018)

The expansion of built-up area, construction activities over natural features cause digression and destruction of existing geomorphic features of the urban area.

The city is experiencing massive Urbanization on account of a rapid population increase caused by natural growth and mass migration from rural to urban areas in search of better living and employment opportunities and also due to merger of several villages as a result of spatial expansion of the city from time to time. A case study of Srinagar was used as reference for analyzing various socio-economic indicators of urban importance. Land use, though the vital indicator of fringe delineation was ignored due to the merger of vast tracts of agricultural and vacant land in the city limits. It showed that the expanded fringe area has direct impact on socio-economic and demographic structure (Nengroo, 2012)

The population pressures, socio-economic changes, civic services and fragmentation of

institutional responsibilities lead to decline in the quality of life and living environment in fringe areas. These fringe areas poses tremendous challenges to urban governance, planning, finance and delivery of civic infrastructure and also poses questions to the sustainability of such development on urban fringe (Nallathiga, 2015)

The objectives of the study are:

1. To monitor the growth of fringe zones of Nagpur urban area in past three decades.
2. To map the changing landuse with respect to built-up area, transportation, impact on surrounding agricultural land.

Hypothesis: The expansion of fringe areas of Nagpur city is the effect of Urbanization. Urban built-up areas have negative impact on fringe sustainability.

Study Area:

Nagpur is the second capital of Maharashtra and the third largest city in the state. Nagpur city is one of the fastest growing cities in terms of development. Main fringes of Nagpur city are identified as Koradi and Kamptee in north, Kapsi at east, Butibori at south and Hingna in west directions.

Koradi is a town situated at the distance of 14 km from Nagpur city centre. A thermal Power Station (KTPS)is located in Koradi which is one of the nine active TPS in Maharashtra. Koradi town is also famous for ancient temple dedicated to Goddess Shree Mahalaxmi Jagdamba.

Kamptee is another major fringe situated at 15 kms to the northeast of Nagpur city at the bank of Kanhan river. It is a military cantonment established under British rule.

Kapsi town is located at east along Raipur Road and situated very close to the NMC boundary.

Hingna is an industrial suburb of Nagpur city located westward at 15.6 km distance from Nagpur city at the bank of Vena River. Butibori is another industrial suburb of Nagpur located at 28 km on Wardha road at south of Nagpur. This is the most developed fringe of the city.

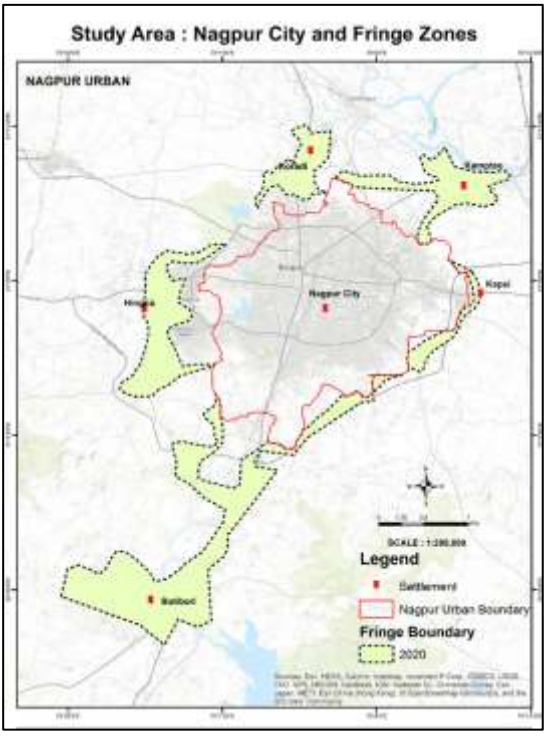


Fig. 1. Study Area: Nagpur City and Fringe Zones

Methodology:

The data collection was done using physical survey, interviewing methods, questioner circulation (online and offline). Secondary datasets were procured from NMC authorities in the form of DPR, annual reports published by Nagpur Municipal Corporation (NMC) for the years 2001, 2012, 2015 & 2019; information available on official websites of NMC, Census of India (2001, 2011, 2021) etc. Images were acquired from sources like ISRO's Geoportal 'Bhuvan' and topographical maps published by Survey of India.

Survey:

Physical Survey:

A survey was carried out by physically visiting the fringe zones of Nagpur city. Nagpur city has two ring roads and most of the fringes lie in between those rings.

The survey route was planned with a buffer of 10 km from the city centre in each direction. Total 13 locations around Nagpur city were surveyed namely Butibori, Kamptee, Kapsi, Hingna, Koradi, Wadi, Wanadongri, Khapri, Dighori, Pardi, Panjara, Fetri and Khasala. Photographs of infrastructures, facilities and road conditions were captured.

Fig. 2. Nagpur Infrastructure

Online Survey:

The virtual survey forms were created using Google online service and circulated amongst various social groups. The nature of google forms is MCQ with special reference to migration of people towards Nagpur city. The responses were compiled and then categorized as per various parameters for further use. The google form can be acquired using following link.

https://docs.google.com/forms/d/e/1FAIpQLSemoNF3BsDkxFxuecSllHfX3fPk38b5Zl2JJnIFKa4JtDa_5A/viewform

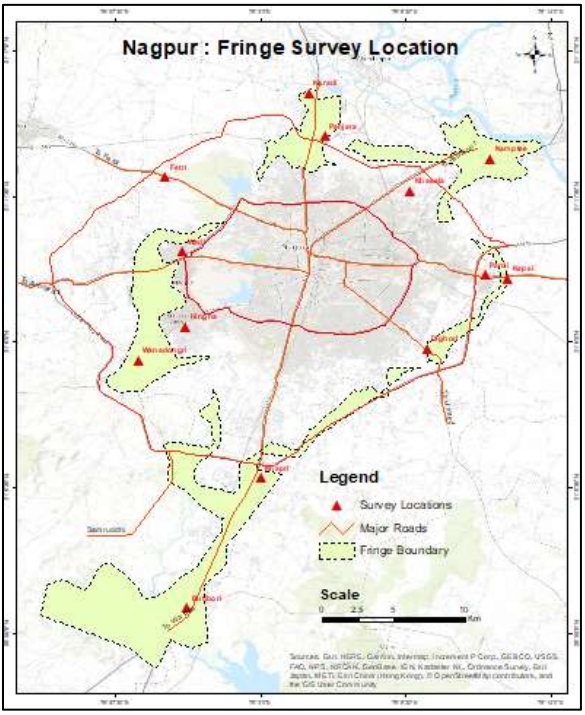


Fig. 3. Nagpur: Fringe Survey Locations

Sources: *Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBas*

e, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, © OpenStreetMap contributors and the GIS User Community

Data Collection

The Topographical Maps no. F44N3, F44N4, F44M16 and F44S13 of the Nagpur Urban areas were procured from the office of The Survey of India, Yerwada, Pune.

The annual reports published by Nagpur Municipal Corporation (NMC) is another major source of authentic information regarding urban development. (CDP, 2015). It gives an account of newly added layouts, authorised buildings and NA plots. The Population data was acquired from the Census of India.

Results & Discussion

Metropolitan enlargement refers to the expansion of urban regions outward. As more people move to nearest city, from nearby and far-flung rural-urban areas, the demand for property develops. It became a source of development for the metropolitan city region's peri-urban or suburban zone. The benefits and drawbacks of growing a city area typically coexist. (Ojha, 2022)

Using Remote sensing and GIS tools, the process of Georeferencing and Digitization were accomplished and final Map of '*Decadal Growth in Fringe Areas of Nagpur City'* was generated.

Fringe is the transition zone between urban and rural areas which begins at the point where agricultural land uses appear near the city. These peculiarities give way to the emergence of different sets of characteristics of rural-urban fringe such as changes in land use pattern, changes in occupational structure, changes in demography, changes in social attributes, presence of factories, warehouse, airports, and transportation hub, etc. (Yadav, 2010)

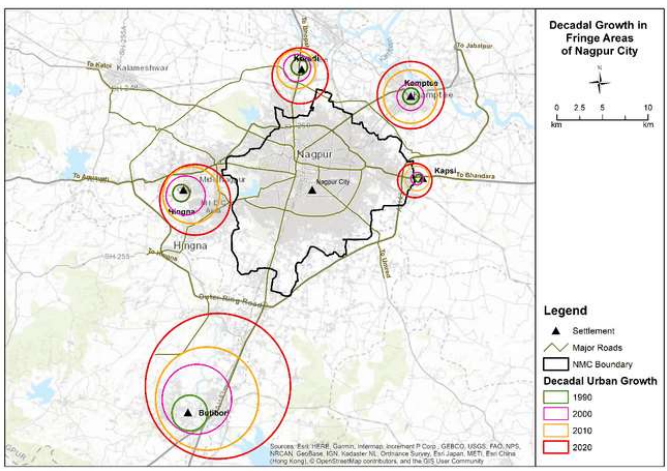


Fig. 4. Decadal Growth in Fringe Areas of Nagpur City

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Interpretation of Map and reasoning:

The map shows decadal growth of fringe areas from the year 1990 to 2020. The area wise growth is depicted with concentric circles each representing the expansion in a span of 10 years. The map illustrates that the maximum urban expansion happened in the southern fringe that is Butibori area while the minimum is at Kapsi in east.

Hingna also shows a noticeable urbanisation due to development of surrounding landscapes with growing number of industries and other infrastructure. Koradi town is already urbanised and well developed due to KPTS and since last few years, it has also emerged as a well-known religious place.

Kamptee is an army cantonment and it is also a religious centre of Buddhisim. Situated on Nagpur- Jabalpur Highway, its location is beneficial from the tourism point of view. It serves as a gateway to 'Pench Tiger Reserve' and many resorts and jungle

safaris has been established in this area. The town also hosts a Buddhist monument called 'The Dragon Palace' and thus attracts tourist.

Butibori shows the maximum urbanisation as it has the most advantageous location along NH- 44 and proximity to the airport, metro line and MIHAN project. Many new built-up has been raised between NMC boundary and Butibori town. The VCA international cricket ground is also situated within this fringe area.

Nagpur city fringe areas host many newly established educational institutes spreading around almost 20 kms of distance from the city boundary. These institutes were mapped and classified on the basis of date of establishment as before and after the year 2010.

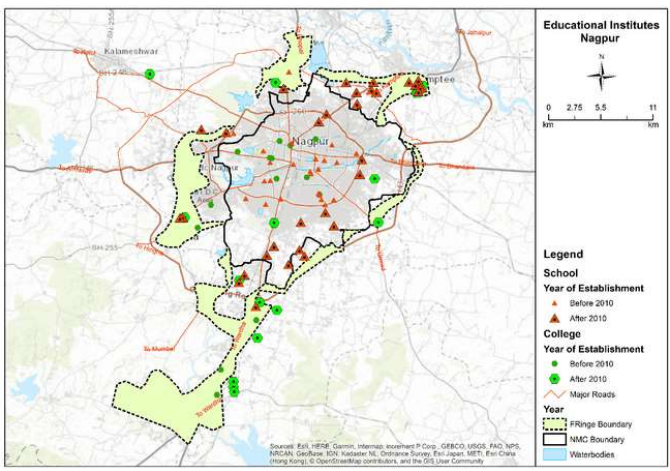


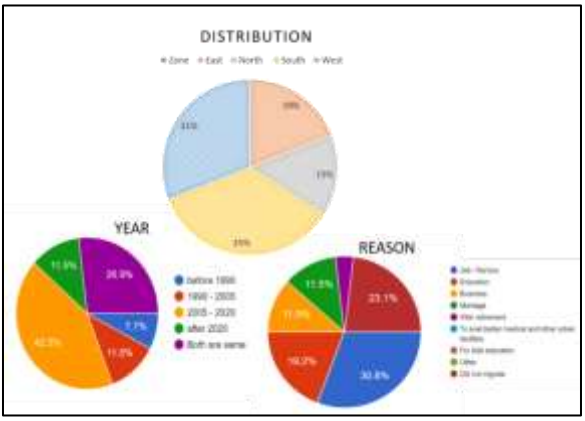
Fig. 5 Educational Institutes of Nagpur

The major educational institutes like Symbiosis, Maharashtra Law University, Indian Institute of Information & Technology, Central India School of Fine Arts, Kalidas Sanskrit University, Bhavan's Vidya Mandir, Delhi Public School, D.Y. Patil Schools, etc established their campuses in the south fringe of the city and hence the region has seen the maximum urban growth.

Fringe Town	Distance from NMC boundary in km	Total Area (Sq. Km)
Butibori	0.8	77.77
Hingna	0.3	30.54
Kamptee	3	23.1
Kapsi	1.9	7.14
Koradi	1.3	15.09

The survey results also reflects that the most of the non-native people who shifted to Nagpur prefer to reside in the fringe zones than the core /old parts of the city. It is also observed that the most of the respondents have migrated to Nagpur between year 2005-2020. The reason being increase in the total extended areas during that period and reason is for job/ service or education. Business and marriage are also the grounds for migration.

Majority of the residents are Marathi speaking people from surrounding areas mostly from Vidarbha, Madhya Pradesh and



Chhattisgarh. Among them 35% reside in the southern fringe of the city followed by west (31%), east (19%) and least in north with 15%.

Change Detection:

This technique is used to compare the Land Use Land Cover (LULC) of Nagpur fringe, assuming the current urban area as the control variable, in the span of years 1990 to 2020. There is a noticeable change in fringes. The agricultural land surrounding the city has been reduced from 43.22% to 27.14% and to converted to built-up giving a rise from 23.41% to 56.56%. There is a concerning decrease in the vegetation which is from 17.13% to 8.09%.

Land Use Land Cover	1990		2020	
	Area (Sq.Km)	%	Area (Sq.Km)	%
Agriculture	170.08	43.22	106.78	27.14
Open	61.55	15.64	29.57	7.51
built-up	92.13	23.41	222.56	56.56
Vegetation	67.40	17.13	31.82	8.09
Water Bodies	2.33	0.59	2.76	0.70

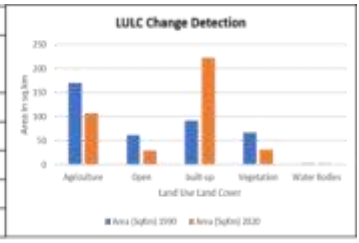


Fig.6 Temporal Account of Urban Development

***(Source**: Image Landsat / Airbus@2010 and Airbus, Maxer Technologies, MapData@2020)*

Visible changes can be tracked with following subsequent years. Nagpur city has experienced a drastic transformation in terms of size, shape as well as the identity.

The adjacent image shows a noticeable urban development in terms of built-up and transportation infrastructure in MIHAN area (Southern fringe) within a decade.

The same scenario is almost in every fringe of the Nagpur city.

***(Source**: Image Landsat / Airbus@2010 and Airbus, Maxer Technologies, MapData@2020)*

Consequences

Positive

- Urban regions evolve naturally and go through stages of development that are observable and consistent. Following the construction and occupancy of the new housing projects, the new residents see the need for new schools and upgrades in the roads, sewage, and water supplies to service the newly constructed homes. This increased infrastructure subsequently draws in more homes at higher densities. Businesses and retail malls follow the population after a certain mass is reached in order to better serve and be nearer to the labor force.
- New job/ business opportunities are created due to urban expansion. Numerous industrial cities are created as a result of rapid industrialization. Urban areas are seeing the creation of new and more jobs in the recently growing manufacturing and service sectors. This led to the establishment of the industrialization-urbanization process and migration from rural to urban areas. The Butibori fringe at south of Nagpur is a good example of this. Due to commencement of MIHAN cargo -hub project, many industries have established their extended campuses in Butibori creating many jobs to locals as well as migrants.

- Many new educational institutes were established along the fringes that play a vital role in urban expansion. They act as the reason in boosting up the growth of supportive infrastructure like hostels, paid accommodations, restaurants, clinics, stationary stores, etc in the adjoining areas. The Hingna-Vanadongri suburb of Nagpur is the suitable case. Emergence of numerous new service providers and business activities are observed in Hingna fringe.
- Good transportation structure is developed for rapid access to the fringe areas. Since infrastructure provides the necessary framework for development, investments in roads, sewers, and water supplies can be one of the most significant drivers of development of fringes.
- Modernization and behavioural changes are observed in the in the attitude of citizen residing in the fringe zones. As a result of urbanization, people's attitudes and thoughts change, leading to modern behaviour and appropriate motivation, which indirectly accelerates the nation's economic development.

Negative

- One major factor contributing to the growing urbanization is increasing congestion. Overcrowding has given rise to issues like traffic jams and excessive population density.
- More migrated population from different cultural backgrounds may lead to social conflict between localities and migrants. Fortunately, Nagpur rural-urban fringe zones have witnessed very less cultural conflicts. However, the crime rate of the city has been significantly increasing.
- An excessive number of people leads to urban turmoil in terms of housing, medical facilities, slum expansion, violence, crowded living conditions, etc. leading towards a poor quality of living. Each of these would cause the standard of living for people to decline.
- A significant number of people change from rural to urban lifestyle. However, such a significant transformation of the working population from rural areas would cause productivity losses there, which would worsen the economic situation in the village.
- Land use change: The agriculture between fringe town and Nagpur city has seriouslyhampered and most of the land is converted to either built-up or transportation.

Land Use Land Cover	Area (Sq.Km)
Agriculture	-63.30
Open	-31.98
built-up	130.43
Vegetation	-35.58
Water Bodies	0.43

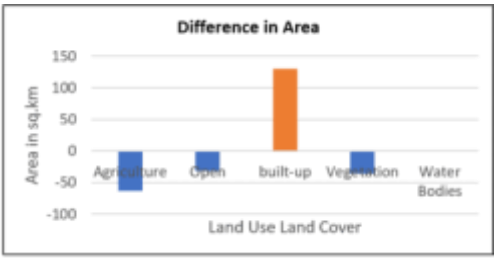


Fig. 7 Difference in area of land use cover

Findings and Conclusion:

The study focuses on the role of urbanisation and its overall impact on the Landuse Land Cover of the Nagpur fringe areas. The rapid growth in the built-up area, with a decrease in vegetation, agriculture and open land was found.

Fringe area has experienced rapid growth in population due to migration of people from surrounding area after the year 2000. However, the rate of migration is now slightly decreased as compared to the previous decade.

References:

1. Ahnert, F., Ahnert, F. O. (1998). Introduction to Geomorphology. United Kingdom: Arnold. pp. 352.
2. CDP (2016). City Development Plan for Nagpur, 2041, Capacity Building for Urban Development project (CBUD). Ministry of Urban Development, Government of India. https://www.projectstiger.com/project/project-brief/374
3. ESRI (2021, December 7). Types of network analysis layers. ArcGIS Desktop. Retrieved September8, 2023, from https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/network-analysis-layers.htm
4. Gallent, N., Shoard, M., Andersson, J., Oades, R., & Tudor, C. (2004). Inspiring England's urban fringes: Multi-functionality and planning (9th ed., pp. 217-233). Local Environment. https://doi.org/10.1080/1354983042000219342
5. https://earth.google.com/web/@21.17058803,79.07757625,325.07108213a,55207.41293871d,35y,-4.75619449h,1.07964568t,-0r
6. https://maps.apple.com/place?address=Nagpur,%20Maharashtra,%20India&auid=6678497678372893858&ll=21.149693,79.109265&lsp=6489&q=Nagpur&t=m
7. https://www.aqi.in/dashboard/india/maharashtra/nagpur
8. https://www.macrotrends.net/cities/21347/nagpur/population
9. Huggett, R., Shuttleworth, E. (2022). Fundamentals of Geomorphology. United Kingdom: Taylor & Francis. Pp 228-231
10. Jin, Y. (2012, November). Study on Urban Fringe Area Planning and Design under the Background of New Rural Construction. Advanced Materials Research, 598, 229–232. https://doi.org/10.4028/www.scientific.net/amr.598.229

11. Khan, F., Das, B., Mishra, R. K., & Patel, B. (2021). Analysis of Land Use Land Cover Changes with Land Surface Temperature Using Spatial-Temporal Data for Nagpur City, India. Journal of Landscape Ecology, 14(3), 52-64. https://doi.org/doi.org/10.1007/
12. Nallathiga, R., Gangal, B., Gupta, A., & Taneja, S. (2015). Sustainability of Urban Fringe Development and Management: A Case Study of Fringe Area of NCT – Delh. National Conference on "Urbanisation and Sustinability" by IDS Kolkata and IIT BombayAt: Kolkata.
13. https://www.researchgate.net/publication/270894918_Sustainability_of_Urban_Fringe_Development_and_Management_A_Case_Study_of_Fringe_Area_of_NCT_-_Delhi
14. Nengroo, Z., Bhat, M., & Kuchay, N. (2012). Delineation of Rural-Urban Fringe - a Case Study of Srinagar City. INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT, 1(4), 17-37. https://doi.org/10.24940
15. Ojha, V. (2022). URBAN FRINGE TRANSFORMATION AND ENVIRONMENTAL DEGRADATION: A CASE STUDY OF AHMEDABAD. International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS) 101, 04(01), 101-115. https://doi.org/doi.org/10.56293/IJMSSSR.2024.4804
16. Polyzos, S., Minetos, D., & Niavis, S. (2013). RIVING FACTORS AND EMPIRICAL ANALYSIS OF URBAN SPRAWL IN GREECE 5 DRIVING FACTORS AND EMPIRICAL ANALYSIS OF URBAN SPRAWL IN GREECE Spyros NIAVIS. Theoritical and Emperical Researches in Urban Management, 8(1), 5-29.
https://www.researchgate.net/publication/338159595_Polyzos_S_Minetos_D_and_Niavis_S_DRIVING_FACTORS_AND_EMPIRICAL_ANALYSIS_OF_URBAN_SPRAWL_IN_GREECE_5_DRIVING_FACTORS_AND_EMPIRICAL_ANALYSIS_OF_URBAN_SPRAWL_IN_GREECE_Spyros_NIAVIS
17. Pramono, R. (2018). Housing Development on the Urban Fringe and its Challenges to Sustainable Urban Growth. IOP Conference Series: Earth and Environmental Science, 158(1). https://doi.org/10.1088/1755-1315/158/1/012042
18. Yadav, A. K. (2010). The Impact of Urbanization on the Agricultural Land Use a Case Study of Allahabad Fringe Area [Doctoral dissertation, University of Allahabad]. http://hdl.handle.net/10603/261903

Facts and Effects of Plastic Wastes Disposal

Sudhakar J. Borase
Assistant Professor, Department of Geography, RNC Arts, JDB Commerce and NSC Science College Nashik Road, Nashik, Maharashtra, India.
Email- *borasesudha@gmail.com*

Article DOI Link: https://zenodo.org/records/10559229
DOI: 10.5281/zenodo.10559229

Abstract:

Plastic pollution is a serious global concern and a major contributor to climate change. It's no secret that plastic is terrible for the environment, according to the UN Environment Program (UNEP) 300 million tons of plastic are produced every year and not all of it is recycled. To put that in perspective, that's about the weight of the entire human population. Some countries and cities around the world have implemented plastic bags, and demand to phase out single-use plastics is at an all-time high, but more needs to be done. Some governments and organizations are doing their part to reduce plastic use and improve the environment. Some retailers have also taken responsibility for the environment and committed to reducing the amount of plastic they produce. Meanwhile, plastic straws and cutlery have been targeted by countless retailers across the board, and in some countries just having a plastic bag is enough to land you in jail. It is also up to us as consumers to understand the environmental impact of using plastic. Between 1950 and 2021, an estimated 390.7 million metric tons of plastic were produced worldwide, of which 9% and 12% were recycled and incinerated, respectively. Human population growth and continuous demand for plastic and plastic products has led to a steady increase in plastic production, plastic waste generation and consequent environmental pollution.

Keywords: Plastic pollution, environmental impact, plastic use.

Introduction:

Plastics are synthetic organic polymers used extensively in various applications, from electronics to construction materials. Initially considered harmless and durable, plastics have become a major environmental concern. Disposal of plastic waste into the environment has led to significant problems, especially in aquatic environments. Plastics undergo long-term biophysical degradation; Limited options for plastic disposal contribute to their persistence in the environment. Sheeting and packaging plastics, due to their durability, are ubiquitous and persist long after their initial use. Research on the monitoring and impact of plastic waste is still in its early stages, but initial reports indicate alarming findings. Plastics made from gasoline-based polymers are abundant in commercial and residential environments. Disposal of such plastics often involves filling them with municipal solid waste. Plastics contain various

toxic substances, including phthalates, poly-fluorinated chemicals, biphenyl, brominates flame retardants, and antimony trioxide.

These substances can have adverse effects on both the environment and public health. Plastics in electronic waste pose a serious concern globally due to large-scale production and inadequate management policies in many countries.

Objectives:

1. To know information in context Plastic manufacturing and global products
2. To know the facts about plastic use and plastic pollution
3. To know the Effects of Plastic pollution
4. To suggest measures to reduce plastic pollution by creating awareness in society regarding plastic usage

Methodology: The methodology of present work includes secondary data. The secondary data collected through varies books, research papers, journals and internet.

Global Production Of Plastic And Generation:

Historical Development: Evidence of human use of plastic dates back to prehistoric Mesoamerica around 1600 BC. The discovery of polystyrene (PS) and vulcanized rubber in 1839 marked the beginning of various applications and the production of plastics and plastic products.

Discovery of Bakelite: Belgium produced Bakelite, the first real synthetic polymer, in 1907.

Bakelite became widespread in the 1930s, especially in the fashion, transportation, electrical, and automotive industries.

Mass Production and Expansion: Mass production of plastic began in the 1940s, leading to continuous expansion. By 2021, global plastic consumption had reached 8.3 billion tons annually.

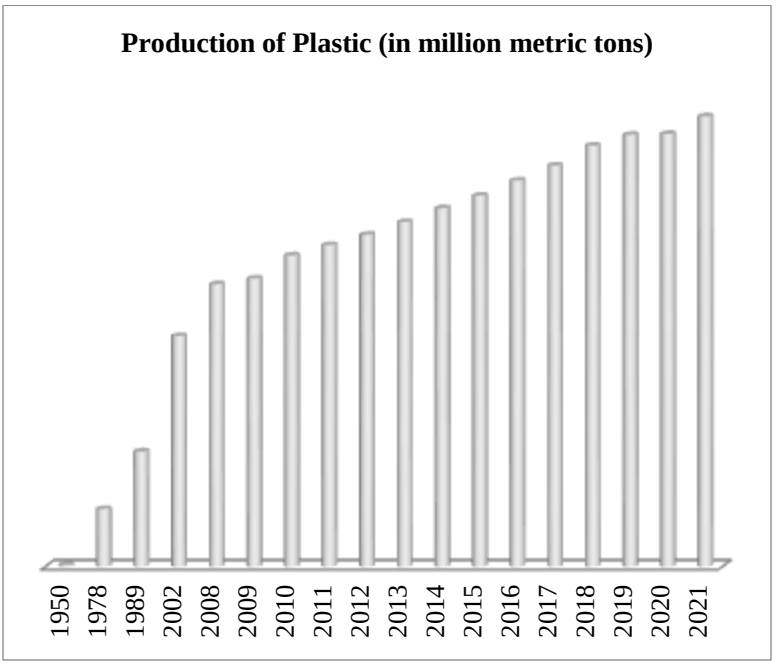
Sector-wise Consumption: Single-use packaging emerged as the largest sector, constituting about 40% of total plastic consumption in Europe. Other sectors included consumer goods (22%), construction materials (20%), automotive (9%), electrical (6%), and agricultural applications (3%).

Regional Production Distribution: In 2015, Asia had the highest rate of plastic production, accounting for 49% of total global production. China stood out as the largest global producer, contributing 28% of the world's plastic production. North America and Europe each accounted for 19% of global production.

Annual Production of Plastics Worldwide From 1950 To 2021

Sr. No	Year	Plastic Production (in million metric tons)
1	1950	1.5
2	1978	50
3	1989	100
4	2002	200

5	2008	245
6	2009	250
7	2010	270
8	2011	279
9	2012	288
10	2013	299
11	2014	311
12	2015	322
13	2016	335
14	2017	348
15	2018	365.5
16	2019	374.8
17	2020	375.5
18	2021	390.7



Source: https://www.statista.com

Some Plastic Pollution Facts:

1. Only 9% of all plastic produced is recycled: According to a report from the Guardian, an estimated 8.3 billion tons of plastic have been produced since the 1950s UNEP reports that only 9% of all plastic is recycled and 12% is incinerated. The remaining plastic has polluted the environment Initiatives include improving recycling technologies, investing in infrastructure, raising awareness about proper recycling practices, and developing more sustainable alternatives to traditional plastics. Increased collaboration among governments, industries, and consumers is crucial to improving the overall recycling rate and mitigating the environmental impact of plastic waste.
2. A whopping 2 million plastic bags are used every minute worldwide: according to Ecowatch, between 500 billion and 1 trillion plastic bags are used worldwide annually. Plastic bags contribute significantly to environmental pollution.
3. Single-use plastics are illegal in some parts of the world: Kenya introduced one of the world's toughest laws against plastic bags in 2017. Now, Kenyans who are caught producing, selling, or even using plastic bags will risk imprisonment of up to four years or large amount fines Other countries that have banned, partially banned, or taxed single-use plastic bags include China, France, Rwanda, and Italy. India has taken steps to tackle plastic pollution, and some states have implemented bans on single-use plastics. For example, Maharashtra was one of the first states to ban plastic bags in 2018.
4. Every minute of every day a truckload of plastic is dumped into the ocean: According to a study by the World Economic Forum, 32% of all plastic packaging produced finds its way to our oceans every year; this figure is the equivalent of pouring one garbage truck of plastic into the ocean every minute.
5. 73% of beach litter worldwide is plastic: According to National Geographic, 73% of all beach litter is plastic. The litter includes filters from cigarette butts, bottles, bottle caps, food wrappers, grocery bags, and polystyrene containers.
6. One million plastic bottles are bought every minute: A report by the Guardian found that 1 million plastic bottles are purchased around the world every minute, and this number is set to increased by another almost 25% by 2023 if we don't act. The same report said more than 480 billion plastic drinking bottles were purchased in 2016 across the world — up from 300 billion a decade before.
7. There could be more plastic than fish in the ocean by 2050: A report by the Ellen MacArthur foundation in partnership with the World Economic Forum found that if plastic pollution continues at this rate, the amount of plastic in the ocean could outweigh the amount of fish.

8. Up to 95% of plastic polluting oceans are carried by 10 rivers: According to World Economic Forum researchers, 88 - 95% of plastic waste that is washed into oceans by 1,350 large rivers around the world comes from just 10 rivers across Asia and Africa. The study states that eight of these rivers are in Asia: the Yangtze, Indus, Yellow, Hai He, Ganges, Pearl, Amur, and Mekong. Two of the rivers can be found in Africa: the Nile and the Niger.

9. 99% of seabirds will be eating plastic by 2050: According to the United Nations, ingestion of plastic kills an estimated 1 million marine birds and 100,000 marine animals each year, and scientists believe that if plastic pollution continues at this rate, 99% of the world's seabird species will be ingesting plastic by 2050. Additionally, more than 90% of all birds and fish are believed to have plastic particles in their stomach. It's because plastic breaks up into tiny pieces in the sea, which are then consumed by fish and other sea animals.

10. The average person eats 70,000 micro plastics each year: That works out to about 100 bits of micro plastic over the course of just one meal, according to a study published in Environmental Pollution. The report predicts that oceans will contain at least 937 million tons of plastic and just 895 million tons of fish by 2050.

11. The average time that a plastic bag is used is just 12 minutes: plastic bag used for an average of 12 minutes and then take up to a thousand years to decompose.

12. Over the past 50 years, world plastic production has doubled: In 1974, global plastic consumption per year was 2 kilograms per capita. Today, this has increased to 43 kilograms and this number is still set to increase. If plastic consumption increases at its current rate, according to National Geographic, by 2050 there will be 12 billion metric tons of plastic in landfills.

Current World Polyethylene Terephthalate:

High-density polyethylene: Polyethylene terephthalate (PET) is a type of plastic that is smooth, transparent and relatively thin. It is also called stomach plastic. PET is commonly used in the manufacture of disposable salad dressings, juices, mouthwashes, vegetable oils, cosmetics, soft drinks, margarine and water bottles, as it is anti-inflammatory and completely liquid. PET is also anti-air, preventing the entry of oxygen into it.

Polyvinyl Chloride (PVC) : Economical, versatile polyvinyl chloride (PVC, or vinyl) is used in a variety of applications in the building and construction, health care, electronics, automobile and other sectors, in products ranging from piping and siding, blood bags and tubing, to wire and cable insulation, windshield system components and more.

Low-density polyethylene: LDPE is widely used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic parts for computer components, and various molded laboratory equipment. Its most common use is in plastic bags.

Polypropylene: It is a kind of strong and semi-transparent plastic. It is used for packaging medicine, yogurt, ketchup, beverages etc. Plastics made from polypropylene contain no harmful substances and like polyethylene, polypropylene containers are considered safe for human beings.

Polystyrene: Polystyrene, a type of petroleum-based plastic, contains benzene which is carcinogenic to humans. Polystyrene is commonly used in the manufacture of insulators and packaging materials. Styrene products are harmful to health.

Polycarbonate: Polycarbonate is used for packaging consumer goods such as reusable bottles. Due to high temperature exposure, BPA can be poured from polycarbonate containers into beverages or stored food. As health risks of BPA have been reported in many studies, the use of polycarbonate plastics has been greatly reduced.

Size of Plastics:

The size of plastics can vary widely, ranging from macro plastics to micro plastics and even smaller particles. Here are the general categories:

Macro plastics: These are visible pieces of plastic that are larger than 5 millimeters in size. Examples include plastic bottles, bags, containers, and other items commonly found in the environment.

Micro plastics: Micro plastics are much smaller, typically ranging in size from 5 millimeters down to 0.1 micrometers. They can be further divided into two categories:

Primary Micro plastics: These are intentionally produced small plastic particles used in products like personal care products (micro beads) or as pellets in manufacturing.

Secondary Micro plastics: These result from the breakdown of larger plastic items into smaller particles through weathering, degradation, or mechanical processes.

Nan plastics: Nan plastics are even smaller than micro plastics, measuring less than 0.1 micrometers. They can be formed through the further degradation of micro plastics or as a result of industrial processes.The environmental impact of plastics varies based on their size. While macro plastics can pose threats to larger organisms, micro plastics and nanoplastics are of increasing concern due to their potential ingestion by smaller organisms and the potential for these particles to enter the food chain. Efforts to address plastic pollution often involve strategies to reduce the use of single-use plastics, improve recycling systems, and develop alternatives that are more environmentally friendly. Monitoring and research on the presence and impact of plastics in various environments continue to be areas of active study and concern globally.

The environmental impact of plastics varies based on their size. While macro plastics can pose threats to larger organisms, micro plastics and nanoplastics are of increasing concern due to their potential ingestion by smaller organisms and the potential for these particles to enter the food chain. Efforts to address plastic pollution often involve strategies to reduce the use of single-use plastics, improve recycling systems, and develop alternatives that are more environmentally friendly. Monitoring and research on

the presence and impact of plastics in various environments continue to be areas of active study and concern globally.

Land Filling: Approximately 10% of household waste is plastic and most of it ends up in landfills. Although land filling is the most common waste management traditional approach in many countries, lack of space for landfill is becoming a major problem. Environmental and public health concerns about the potential consequences of landfills are growing because of the type and quantity of toxic chemicals and their potential for leaching at landfill sites. They are free from burning in plastic environments. Loss of plastic combustion is caused by air pollution caused by harmful fumes released into the atmosphere.

The combustion heaters of the flue system are permanently damaged by the plastic during the burning of the plastic and these plastic combustion products are harmful to both humans and the environment. Some plastic combustion products can react chemically with water and the resulting compounds can change the pH which can change the function of aquatic ecosystems. The percentage of plastics can be increased with the possibility of full recycling instead of being generated as a large amount of waste if good manufacturers reduce the mixture of packaging material and remove contaminants. With this in mind, the Association of Plastic Recyclers has issued a design guide for recycling plastics. The amount of recycled post-consumer plastics has increased since 1990.

Recycling of plastics:

Plastic recycling is the process of recycling confiscated plastic scrap into disposable products. Most plastics are non-biodegradable in nature, therefore, reducing waste emissions, resulting in effective waste management and recycling is a fundamental task. Plastic recycling is a major part of the global effort to reduce the 8 million tons of plastics that enter the Earth's oceans annually. Recycling plastics is more challenging due to the lower density and lower value compared to the recycling of ferrous metals but also the lower value of recycling glass. Also, the recycling of plastics involves a number of technical issues. When different types of plastics are melted together, they undergo phase-separation like oil and water and they form in these layers. The resulting phase boundaries are responsible for the structural weakness of the final product, which limits the use of this polymer mixture. Polyethylene and polypropylene, two plastics that are commonly produced and therefore their use for recycling is limited. In recent times, block copolymers as macromolecular welding fluxes have been proposed to overcome this challenge of phase-separation during plastic recycling.

Environmental Pollution By Plastic Wastes:

Distribution of plastic waste is associated with human populations. Increase in human population has led to increase demands for plastics and plastic products. Indiscriminate disposal of wastes from plastics and plastic products can lead to

environmental pollution which is evident in several ways including environmental natural beauty deterioration entanglement and death of aquatic organisms, sewage system blockage in towns and cities especially in developing countries, resulting in creating conducive environment for breeding mosquitoes and other disease causing vectors and production of foul smells, reduction in water percolation and normal agricultural soils aeration thus causing reduced productivity in such lands.

Land Pollution:

In human occupational and residential environment, plastic products are present in large volume. Pollution by plastics and plastic products can damage and contaminate the terrestrial environment and can be subsequently transferred to the aquatic environment. There is a shortage of data on the volume of plastic wastes on land in comparison to the voluminous data which exist on plastic debris in marine habitat, despite the fact that about 80% of plastic waste present at sea originates from land-related sources. Dumping of plastics on land or land filling plastics leads to Abiotic and biotic degradation of the plastics, where plastic additives (e.g. stabilizers, harmful colorant moieties, plasticizers and heavy metals) can leach and eventually percolate into various aspects of the environment, thereby causing soil and water contamination. Reports have shown that micro plastics as well as synthetic polymer fibers are still detectable five years after they have been applied to sewage sludge and soils. Chlorinated plastics are capable of leaching out toxic chemicals into the soil and subsequently seep into the underground water or surrounding aquatic system thereby polluting the ecosystem. Methane, a dangerous greenhouse gas, which significantly contributes to global warming, is released during microbial biodegradation of plastics.

Approximately 165 million tones of plastic wastes were estimated to be present in the oceans of the world in 2012, while an average of 8 million tones of plastics is annually released into the ocean, with about 5 trillion plastic pieces floating on the ocean]. Typically, plastics in the oceans can degrade within a year but not completely. During this plastic degradation process, toxic chemicals like polystyrene and BPA can be released into the water causing water pollution. Wastes found in the oceans are made up of approximately 80% plastics. Plastic debris which are floating on the ocean can be rapidly colonized by sea organisms and due to persistence on the ocean surface for a long period of time, this may aid the movement of 'alien' or non-native species. Contaminants from micro plastics are bio available for many marine lives because of their presence in benthic and pelagic ecosystems and their small sizes. Within the marine ecosystem, plastics have been reported to concentrate and sorbs contaminants present in the seawater from different other sources. More than 260 species of marine organisms such as turtles, invertebrates, seabirds, fish and mammals ingested or are entangled in or with plastic debris, leading to reduced movement, feeding, reproductive output, ulcers, lacerations and eventual death.

Air Pollution:

Carbon dioxide and methane are released into the air when plastic wastes which were land filled finally decompose. During the decomposition of solid waste in landfills in 2008, an estimated CO_2 equivalent ($eqCO_2$) volume released into the atmosphere was 20 million tones. CO_2 is also released into the atmosphere during the burning of plastics and plastic products, and this CO_2 is capable of trapping radiant heat and hinder it from escaping from the earth causing global warming]. Air pollution is one of the major environmental threats to public health, and it is responsible for more than 6 million deaths associated with environmental pollution]. Open burning of plastics and plastic products releases pollutants such as heavy metals, dioxins, PCBs and furans which when inhaled can cause health risks especially respiratory disorders. The role of plastics in air pollution in the developing and poor countries of the world cannot be overemphasized, and the impact on the future generations may be massive.

Effects Of Plastic Wastes:

Effects of Plastic Wastes on Animals

Food supplies for human consumption can be adversely affected if animals are poisoned by toxic constituents from wastes of plastics and plastic products .Indeed, report of threat to survival of large marine mammals have been documented due to large amount of plastic wastes entering the world oceans Animals are exposed to plastic wastes majorly through ingestion and entanglement, however, ingestion is more frequent than entanglement. Most animals in the oceans mistaking plastic wastes dumped in the ocean for food, thereby ingesting them. Furthermore, entanglement in plastic products like nets can cause harm, damage and even death in marine animals. Reports have shown that more than 260 different species of vertebrate and invertebrate animals ingest plastics or are entangled by plastic or plastic products, with more than 400,000 deaths of marine mammals. Marine pollution by plastic wastes majorly affects sea turtles and other species whose main food are jelly fishes because they often confuse discarded plastic bags for jelly fish. A similar situation is common in sea birds which can confuse micro plastics for cuttlefish or with fishes, which can mistake plastic wastes for their natural prey. Ingestion of plastic wastes is capable of causing obstruction and physical damage to bird's digestive system, reduce the digestive ability of the system leading to starvation, malnutrition and eventually, death.

Many birds, turtles, fishes, seals and other marine animals have died by drowning or suffocation as a result of entanglement in plastic debris. Entanglement has been observed to cause health risks in estimated 243 species of marine lives, often ending in fatalities. Animal entanglement by plastic debris also contributes to death from predators, as the animals are unable to untangle themselves and escape. Coral reefs have been damaged by dragging nets and other plastic products along sea beds. Often times, discarded fishing nets also called "ghost nets" trap marine animals, leading to

starvation and death. Table 3 shows the effects of different types of plastics on animals and the mechanism(s) of action.

Public Health Effects of Plastic Wastes:

It is generally believed that plastic polymers are lethargic and of little concern to public health, however, different types of additives and the residual monomers possibly retained from these polymers are responsible for the suspected health risks. Most of the additives present in plastics are potential carcinogens and endocrine disruptors. Ingestion, skin contact and inhalation are the main routes of exposure of humans to these additives. Dermatitis have been reported from skin contact with some of the additives present in plastics. Micro plastics are major contaminants that can bioaccumulation in the food chain after ingestion by a wide range of freshwater and marine lives leading to a public health risk. Human consumption of animals exposed to micro plastics and plastic additives can be detrimental. Bio monitoring studies on human tissues have shown that plastic constituents persist in human population through the measurement of environmental contaminants.

Public Health Effects of Plastic Additives

Different additives are used in the production of plastics and they have been reported to have various detrimental effects on humans. Table 4 shows the different types of additives use in plastic production, their effects and the types of plastics.

Plastic waste management and recycling

In reducing toxic effects of plastic wastes on the environment and public health, waste management plays a major role. For global reduction of plastic litters and ocean pollution, there is need for improvement in proper plastic waste collection, treatment and disposal. Inadequate management of landfills will make way for harmful chemicals in plastic wastes to leach into the environment, polluting the soil, air and underground water.

Proper wastewater management will prevent micro plastics from entering the environment from the landfills. Most treated wastewaters are discharged into rivers or oceans; therefore, there is need for a ban such as Annex V to the International Convention for Prevention of Pollution from Ship (MARPOL) agreement, which will prevent plastic waste disposal into the sea.

Education and public awareness

Efforts must be made to educate the general populace on the potential environmental and public health effect of pollution by plastic wastes. This will go a long way to reduce the pollution rate and preserve the quality of the environment. There is need for people to be aware of the chemical constituents of plastic products and their health effects. Educational curriculums at different levels must include ways of plastic pollution reduction and waste management systems as information resources.

Bioplastics as alternative

Bioplastics is a plastic produced from cellulose that is made of wood pulp by a British chemist in the 1850s. Now, bioplastics can be produced from different biodegradable and non-biodegradable materials including weeds, hemp, plant oil, potato starch, cellulose, corn starch, etc. Sugar-based bioplastics can biodegrade under normal conditions for composting. Bioplastics are environmentally friendly since they require less fossil fuel during production in comparison to other types of plastic.

Although bioplastics have been used commercially in just few applications, they are widely used in consumer goods for items that are disposable like cutlery, bowls, pots, crockery, straws and packaging. In principle, bioplastics can replace petroleum-derived plastics in many applications; however, the problem lies with the cost and performance of bioplastics. If there are no specific regulations globally to limit the use of conventional plastics, there may be no favorable usage of bioplastics. For example, Italy has since 2011 enacted law that made it compulsory for biodegradable plastic bags to be used for shopping. In the production of bioplastics, substitute for fossil fuel resources like wood, cellulose, sugar and starch are used. This has made bioplastics production more sustainable and environmentally friendly in comparison to conventional plastic production. The production of bioplastics decreases consumption of non-renewable energy and reduces the emission of greenhouse gases

We believed that the problem of plastic waste generation and the accompanied environmental and public health effects can be handled if globally, manufacturers can embrace the use of bioplastics. The biodegradability with little or no toxic products left behind will go a long way to protect our natural environment from the menace of conventional plastic wastes, protect our world's organisms and make the world safe for humans.

Conclusion:

Researches on worldwide production of plastics and the accompanied environmental pollution have shown that plastic wastes have constituted a major environmental issue. The effect of plastic wastes on marine organisms, humans and the environment at large is of public concern, and calls for the need to salvage the ecosystems and lives therein. Despite the fact that plastics are very useful in everyday life, the toxic chemicals used in the production need to be thoroughly monitored so as to ensure environmental and health safety. Reducing community's exposure to toxicants from plastic wastes will increase the chances of having a clean environment and healthy society. There is an urgent need for government agencies and health authorities to enact and enforce environmental laws that will monitor production, usage and disposal of plastics. In addition, some harmful chemical constituents used in the production of plastics (e.g. phthalates, BPA, etc) should be banned in consumer goods and in plastic products that are in direct contact with food, beverages and children.

References:

1. Rochman CM, Browne MA, Halpern BS, Hentschel BT, Hoh E, et al. (2013) Policy: Classify plastic waste as hazardous. Nature 494: 169-171.

2. Borase S. J, Effects of space pollution on Environment and Human Health.

3. Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

(2016) Sources, fate and effects of microplastics in the marine environment: Part Two of a Global Assessment. Int Mar Org, London.

4. Obebe S.B., Adamu A.A.(2020) Plastic Pollution: Causes, Effects and Preventions 85-95

5. Subha Ganguli (2018) Plastic pollution and its Adverse effect of Environment and Ecosystem

6. Kaiser J (2010) The dirt on ocean garbage patches. Science 328: 1506.

7. Sepulveda A, Schluep M, Renaud FG, Streicher M, Kuehr R, et al. (2010) A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipment during recycling: Examples from China and India. Environ Impact Assess Rev 30: 28-41.

8. Alabi OA, Bakare AA, Xu X, Li B, Zhang Y, et al. (2012) Comparative evaluation of environmental contamination and DNA damage induced by electronic-waste in Nigeria and China. Sci Total Environ 423: 62-72.

9. Geyer R, Jambeck JR, Law KL (2017) Production, use, and fate of all plastics ever made. Sci Adv 3: e1700782.

10. Borase, S. J. (2021) A Geographical Study of Epidemic Diseases in Nashik District of Maharashtra with Special Reference to Malaria and Dengue

Socio-economic impact of flood: A case study of the Jiadhal River Basin, Dhemaji district, India

Pranamee Gogoi
Ph.D. Research Scholar, Department of Geography, Rajiv Gandhi University, Arunachal Pradesh, India
Email- gogoipranamee30@gmail.com
S. K. Patnaik
Professor, Department of Geography, Rajiv Gandhi University, Arunachal Pradesh, India
Tashi Dorjee Megeji
Assistant Professor, Department of Geography, Bomdila Govt. College, Arunachal Pradesh, India

Article DOI Link: https://zenodo.org/records/10559237
DOI: 10.5281/zenodo.10559237

Abstract:

The Jiadhal River is a sub-tributary of the river Brahmaputra in the district of Dhemaji, Assam. The river causes disastrous floods every year during the monsoon season and is prone to bank erosion, a high amount of sediment deposition in the bed of the river and adjoining areas and extensive flooding. The adverse effect of flood had a great socio-economic impact on the lives of the local people living in the river basin. For the study, an extensive field survey was done in the Jiadhal River basin with a total of 210 household surveys. During the field survey, it was found that regular flood in the monsoon period and vast deposition of sediment in the basin has changed the socio-economic status of the people living in the catchment. The loss of residential areas and agricultural land is a major concern among the local people as most of them are dependent on agricultural activities. This paper is an attempt to explore and understand the impact of flood risk on the socio-economic life of the people based on different flood hazard zones.

Keywords: Jiadhal River, Flood, Socio-economic impact.

Introduction:

Natural hazards or disasters are those types of events which cannot be prevented from occurring but the impact can be reduced with different protective measures (Mili et al., 2013; Yusuf et al., 2023). Extensive flood damages have changed the land use land cover pattern of the floodplain regions of the world (Moghadasi et al., 2018). Flood is considered as a natural hazard unless it is a threat to human life and property (Nott, 2006) but the disasters outbreak of flood is common as the floodplains are mostly suitable for human settlement and developmental activities. Flood is considered an annual phenomenon that has affected millions of people worldwide by destroying lives and

properties, including residential areas, agricultural fields, roadways, bridges, etc. in the floodplain regions of the world. According to Nascimento etal., 2007, flood damages are mostly classified as tangible, intangible, direct and indirect. Many societies have accepted flood as an inevitable phenomenon (Vlachos, 1995) and tried to adapt themselves to the environment.

The flood in Assam is one of the most important environmental problems that disrupts society (Gogoi, 2016) and damages property to a great extent. The state has a long history of floods and the situation is still the same (Saikia & Das, 2002; Gogoi & Patnaik, 2022). Many employment opportunities are also reduced due to less industrial development in the flood-affected areas. Dhemaji, a district in Assam is considered one of the most flood-affected regions. Jiadhal River, one of the major rivers in the district of Dhemaji creates a devastating effect of flood every year, especially during the monsoon season. Flood in the Jiadhal River basin is characterised by extremely high frequency, magnitude and extensive devastation. The impact flood is mostly seen in the middle and lower course of the river. Many studies reveal that the major flood events of the Jiadhal River were recorded in the years 1969, 1973, 1988, 1989, 1992, 1994, 1997, 1998, 2002, 2007, 2009, 2011, 2014, 2017 and 2020. A continuous trend of flood occurrence is seen in the basin after the great earthquake of 1950. Frequent floods in the Jiadhal River catchment cause significant loss of life, properties and severe economic damages.

Over the years, flood has affected many aspects of the lives of the people living in the Jiadhal River basin. Because of its location in the foothill regions of Arunachal Himalaya, the rainfall plays a very important role in creating flash floods in the region which leads to a devastating impact on the people living in the lower course of the river. Every year people lose lives, and properties to flood. Moreover, due to constant changes in the flow of water and the dumping of sediment by the river Jiadhal, the morphometry of the catchment changes after every flood event. Large plots of land including residential areas and cropland are converted into sand dumps and has changed significantly over the past few decades. The structural measures like the embankments, and protection guide banks also failed to protect the people. Therefore, this study helps in understanding the impact of floods on the socio-economic activities among the communities of the Jiadhal River catchment.

Literature Review:

The literature review relating to the study is an attempt to know and have information about the work done earlier and to have a better understanding of the work that is to be done. The literature review includes a wide range of relevant work from different research journals, published and unpublished official reports, official documentation, etc.

Changnon et al., (1983) mentioned in their report that the economic losses to homes, personal property, agriculture, livestock, business facilities and transportation are

major manifestations of flood losses. Floods on large streams as well as on the upstream areas are of great importance as both are responsible for causing serious impacts on human society. Moreover, floods may have some benefits as the river water deposits the nutrients on agricultural lands in the flood plain and the replenishment of groundwater.

Vlachos, (1995), studied the socio-economic impact and consequences of flood and observed that floods are a sociological phenomenon that goes beyond the hydrological conditions. The interaction between society and water resources has produced a changing attitude due to the control over the physical environment and the population expansion, rapid urbanization and increased development in the floodplain region has intensified the impacts of flood on the environment and society.

According to the study done by Nott (2006), flood events are not considered as a natural hazard unless there is any threat to human life physically, psychologically, socially and economically. Nott also categorised the main causes of floods into physical which include the climatological forces and human forces which had a great impact on clearing the vegetation cover of urban development.

While studying about the changes in channel dynamics and morphology of ephemeral rivers Ortega et al., (2014) analysed that human pressure on a river basin may modify the load and discharge relationship including instability on the fluvial river system that manifests abruptly during any flood events.

Debnath et al., (2015), the impact of human interference on rivers has diverse negative consequences and has caused a significant change in the river channel characteristics. Anthropogenic activities like channelization, construction of dams, channel diversion and culverting have a direct consequenceon the river.

Neelofar et al., (2018) define flood as a disaster that has disrupted the human ecology and has exceeded the capacity to function normally among the community. The flood had an overall impact on the livelihood pattern and property which mainly resulted from the delay in the flood warning system, improper evacuation, delay or lack of rescue operation and also due to the lack of preparedness among the community. Floods also had serious consequences on human health like physical injuries, chronic diseases and mental instability which occur during the post-flood scenario.

Allaire, (2018), was of the view that the cost of extreme flood events continues to rise around the world. Many countries are considering the option for risk mitigation and adaptation that include flood control infrastructure, early warning systems and proper land use planning. Moreover, efficient mitigation requires a comprehensive understanding of disaster that has a great impact on society.

Ajiboye & Orebiyi, (2022) while studying the socio-economic impact of floods in Southeast Nigeria said that flooding usually occurs mainly due to natural and anthropogenic causes in nature. The weather and physical landscape mostly enhanced the natural causes of floods while human activities play an important role in causing

anthropogenic floods.

Study Area:

The Jiadhal River of Dhemaji district is an important north-bank sub-tributary of the Brahmaputra River. The extent of the basin is between 27°12'44"N and 27°45'2" N latitudinal and between 94°15'19"E to 94°37'23"E longitudinal. The total area of the Jiadhal River catchment is 1053.20 sq. km of which 696.80 sq. km i.e., 66.16 percentand 356.4 sq. km i.e., 33.84 percent come under Assam and Arunachal Pradesh respectively. The river originates in the West Siang district of Arunachal Pradesh where the three important rivers Sika, Siri and Sido meet at a place called Tinimukh and from there it flows down as the river Jiadhal (Fig.1). After passing through a narrow gorge at Jiadhalmukh, the river debouches on to the plains of Assamcreating my braided channels. The catchment according to the Geological Survey of India is divided into two distinct geological divisions that are – i. the Siwalik formation which belongs to the Tertiary period and ii. The alluvium sediment of the Quaternary period. Due to these two distinct geological divisions, the physiography of the area – i. the mountains and ii. the plains are visible clearly.

The Jiadhal River basin comes under climatic zone – I, where rainfall occurs mostly during the monsoon season and winters remain dry. There can be seen a variation in the temperature, humidity and rainfall within the study area due to its location in the foothills of the Arunachal Himalayan region. The annual rainfall of the basin ranges from 260 cm to 330 cm with an average of 250cm.

Objective of the study: The main objective of the study was to analyse the socio-economic conditions of the people living in the flood-affected areas.

Methodology:

The study is based on both primary and secondary data. The primary data was collected through questionnaires for a total of 210 household surveys in 38 villages based on the distances of 1000 m, 2000 m, 3000 m and 4000 m from the river. The secondary data were collected from different government offices like the Water Resources Department and Circle Office of Dhemaji district and Assam State Disaster Management Website to collect information about affected villages. Table 1 shows the impact of flood hazards on the surveyed villages and Figure 2 shows the impact of flood hazards on the surveyed villages.

Figure 1: Location Map of the Study Area

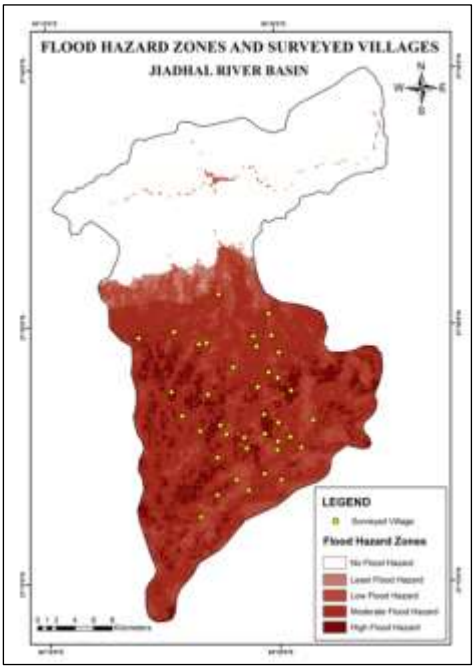
The flood hazard zones map was prepared using the weighted overlay method in ArcGIS 10.8 software. In this method parameters like - the altitude, slope, drainage density, flow accumulation, land-use/land-cover and Geomorphological units. The highest weighted value was considered to be the most flood-affected zone where the risk of vulnerability is higher as compared to the lowest weighted value which is a flood-free zone (Gogoi & Patnaik, 2022).

Table 1: Impact of flood and Villages in Flood Hazard Zones

Impact of Flood	Villages
High Flood	ChakalaDoloni, DihiriChapori, Dihiri Jiadhal (TinighariaKekuri), KadamtalaPathar, Ratua, Samora Jaan
Moderate Flood	Bah-Katika Gaon, Goraimari Gaon, Kakaiyal N.C, Kamalpur, Maralchuk, No. 1 TekjuriPatirsuk, No.2 Gohaingaon, No.2 Tekjuri, Panitula Block, UkhamatiPathar
Low Flood	Baruah Pathar, Batgharia, GarubandhaPathar, Kunwari Bil, Laguabora Block, No.1 Kechukhana, No.3 Tekjuri, Obhaypuria
Least Flood	Bordhekera, Ghilamara ½, Hechuli Pam, Jiadhal DihiriChapori (Tinigharia), NaharbariSalmari N.C, No.1 DharmapurChapori, No.2 Bormutariani, No.5 Tekjuri, Powa Saikia

No Flood	Chechela, Hiloi Para, Kawaimari, No.1 Khalihamari, Panbari (KechaiKhataniAdibashi)

Figure 2: Flood Hazard Zones and Flood-Affected Villages



Source: The map was prepared using the weighted overlay method in ArcGIS by the researcher.

Results and Discussions:

Flood creates great insecurity among the people living in the Jiadhal River catchment. The recurrent threats of flood, bank erosion and embankment failure have always been a matter of concern to the people and the government. The major causes of flood in the basin are –

1. Due to the high intensity of rainfall, the region is located in the tropical monsoonal regime.
2. Due to steep slopes in the hills and flat plains in the lower part of the basin.
3. Due to an increase in deforestation and landslides in the upper catchment of the river. And also because of the shifting nature of the river.

Flood and loss of lives and properties: The immediate impact of flood in the Jiadhal River catchment includes loss of human life, loss of livestock and damages to homestead. During the household survey, it was observed that the impact of flood with high amounts of sediment deposition and embankment breaching are common in the villages situated between the banks of the Jiadhal River up to the distance of 2 km. The villages like

Ghilamara, Salmari, Dhamapur Chapori, Dihiri Chapori etc. had a severe impact of flood and sediment deposition during the monsoon season with high velocity of water discharge.

According to Hazarika, 2010 and Das, 2018 the flood of 1998-2002 affected 680 villages and forty-eight people lost their lives. The flood of 2007 destroyed 30 villages due to the failure of the right embankment near the Kumatiya branch. The impact of the flood created by the Kumatiya River in 2007 can still be seen in several villages. The flood of 2009 was caused by the failure of the left embankment which led to prolonged chaos among 50 villages. Studies also say that the Jiadhal River experienced a wave of five flash floods on 15 August 2011 which affected 85 villages. The flood of May 2020 affected 61 villages and at least 12 roads were damaged that are connected with the villages. Again, in the same year in September, 28 households in the Kekuri village got washed away by flood.

The severe impact of flood forces the people to move to nearby places like embankments, roads, railway lines and schools for shelter. After the situation settles down the people move back to their houses but for some villages, the impact of flood, erosion and sediment deposition is so worse that the villagers have to migrate to another place of settlement. The villages like Jamuguri, Lakhipather and Ratua are the worst examples of flood and sediment deposition where the entire village has been washed away and many people and livestock have lost their lives. Table 2 gives a detailed idea about the impact of floods on different households in different flood hazard zones.

Table 2: Impact of Flood on Households

Impact of Flood	High Flood	Moderate Flood	Low Flood	Least Flood	No Flood	Total Households
F/SD/EB	8			16		**24**
F/SD	25	26				**51**
F/BE	6	6				**12**
RF		26	16	26		**68**
OF			17	12	7	**36**
SD	7					**7**
No					12	
Total Households	**46**	**58**	**33**	**54**	**19**	**210**

Source: Data computed by the researcher based on field survey

F = Flood, **SD** = Sediment Deposition, **BE** = Bank Erosion, **EB** = Embankment Protection, and **OF** = Occasional Flood

Flood and Agriculture: The entire economy of the inhabitants of the Jiadhal River basin is dependent on agricultural activities for their livelihood. Paddy cultivation is the major crop of the basin, also crops like maize, millet, pulses, mustard, black gram, sugarcane and potato are grown. The harvesting season for paddy cultivation starts in the mid of April but the rainfall that occurs from May to mid-October mostly creates floods in the

basin and destroys the cropland. The deposition of sediment and water logging that last fora longer duration in the cropland creates a challenging situation for the local dwellers. The erosional and siltation process in the cropland decreases the growing fertility of the soil. According to Deka, 2008, about 572 hectares of agricultural land have been seriously affected by sand deposition. Different studies also revealed that the 2011 flood in the Jiadhal River basin severely affected 85 villages and 300 hectares of cropland were damaged. In 2019, the NH 15 between Bordoloni and Dhemaji submerged under water which later ledto the entire cropland area being the centre of a unique concentration of unpredictable course of the Jiadhal River. The flood of June 2020 affected 61 villages and destroyed 3474 hectares of cropland.

Table 2 gives a detailed idea about the loss of agricultural land based on the impact of flood on different flood hazard zones. It is found that most of the agricultural land of the surveyed villages was affected mostly by frequent flood and sediment deposition.

Table 3: Impact of Flood on Agricultural Land

Impact of Flood	Sum of Area sown (Bigha)	Sum of Land Loss (Bigha)
High Flood	**316.5**	**107.5**
F/SD/BE	95	15
F/BE	21	19
F/SD	190.5	70.5
SD	10	3
Moderate Flood	**524**	**136.5**
F/BE	66	19.5
F/SD	116	55.5
F	342	61.5
Low Flood	**293**	**23**
F	107	23
EB Protection	186	
Least Flood	**589**	**48**
F/SD	218	48
EB Protection	371	
No Flood	**158**	**13**
EB Protection	118	
OF/SD	40	13
Total	**1880.5**	**328**

Source: Data computed by the researcher based on field survey

F = Flood, **SD** = Sediment Deposition, **BE** = Bank Erosion, **EB** = Embankment Protection, and **OF** = Occasional Flood

Flood and Occupation: The occurrence of flood every year has changed the landscape of the Jiadhal River catchment and it mostly affects the occupational structure. Most of the people in the basin are agrarian in nature and only a few percentages of the population

are dependent on business and animal husbandry.

During the survey with different households, it was found that the families that are involved in wage labour were originally engaged in agricultural activities. Due to the loss of agricultural land to flood and sediment deposition, they had shifted the occupation to wage labour.

Flood and Source of Water: Another major problem faced by the people of the Jiadhal River basin is the source of drinking water. Most of the households in the surveyed villages use handpumps and wells from the nearby government schools. Many people in the affected area save water in water gallons and use them during the time of flood when there is water scarcity. Other people rely on the water supply provided by the government in times of emergency. In some places, due to the unavailability of proper sourcesof drinking water, people directly depend on the river for water sources and as a result, many people suffer from different kinds of water-borne diseases. Later on, such water-borne diseases like malaria, diarrhoea, typhoid etc. cause serious health-related problems among the villagers in the basin area.

Flood and Human Health: The impact of flood, bank erosion and sediment deposition had an adverse effect on people in different ways. The socio-economic impact on the flood-affected people of the Jiadhal River basin has traumatised them for decades. The loss of homeland, displacement from their homes, loss of properties, livestock and human life creates hardship and financial burden and this has also decreased the level of security among the people.

Conclusions:

Floods are of frequently occurring phenomenon in the Jiadhal River basin of Dhemaji district. Moreover, the increasing occupation in the floodplains, and competing and conflicting developmental demands have worsened the impacts of floods on society and the environment. The Jiadhal River is a flashy river and it produces sudden flood with high water discharge and sediment load within a very short period of time. Flash floods with little or no warning cause more causalities and this as a result has a significant impact on human life, agriculture and other livelihood activities. The study shows that many people were displaced from their villages, and many lost their agricultural land, livestock and properties. The stress of overcoming these losses also increases the level of anxiety and depression among people. The impacts of flood could be lessened by issuing early-warning systems and proper maintenance of structural measures, proper health care during the time of emergency and proper management and rehabilitation centres.

References:

1. Ajiboye, O., & Orebiyi, E. (2022). Assessment of socio-economic effects of flooding on selected communities of Anambra West Local Government Area,

Southeast, Nigeria. *GeoJournal*, *87*, 3575–3590. https://doi.org/10.1007/s10708-021-10400-x

2. Allaire, M. (2018). Socio-economic impacts of flooding: A review of the empirical literature. *Water Security*, *3*, 18–26. https://doi.org/10.1016/j.wasec.2018.09.002.
3. Changnon, S. A., Schicht, R. J., & Semonin, R. G. (1983). *A Plan for Research on Floods and Their Mitigation in The United States*.
4. Das, P. J. (2018). Conflicts over embankments on the Jiadhal River in Dhemaji District, Assam. In K. J. Joy, P. J. Das, G. Chakraborty, C. Mahanta, S. Paranjape, & S. Vispute (Eds.), *Water Conflicts in Northeast India* (pp. 147–164). Routledge Taylor and Francis Group. https://doi.org/10.4324/9781315168432.
5. Debnath, J., Ahmed, I., & Das, N. (2015). Impact of anthropogenic activities on channel characteristics: A case study of Muhuri River, Tripura, North-East India. *Archives of Applied Science Research*, *7*(7), 27–36. http://scholarsresearchlibrary.com/archive.html
6. Gogoi, M. (2016). Flood Disaster in Assam: Socio-economic Vulnerability and Control Measures. *South-Asian Journal of Multidisciplinary Studies (SAJMS)*, *3*(6), 2349–7858.
7. Gogoi, P., & Patnaik, S. K. (2022). Remote Sensing and GIS Application in Flood Management: A Case Study of the Jiadhal River Basin of Dhemaji District, Assam, India. In G. S. Bhunia, U. Chatterjee, K. C. Lalmalsawmzauva, & P. K. Shit (Eds.), *Anthropogeomorphology, A Geospatial Technology Based Approach* (pp. 91–104). Springer. http://www.springer.com/series/15117
8. Hazarika, U. M. (2010). Fluvial environment of Jiadhal River Basin, Dhemaji district, Assam. *International Journal of Ecology and Environmental Sciences*, *36*(4), 271–275.
9. Mili, N., Acharjee, S., & Konwar, M. (2013). Impact of Flood and River Bank Erosion on Socio-Economy: A Case Study Of Golaghat Revenue Circle Of Golaghat District, Assam. *International Journal of Geology, Earth and Environmental Scieces*, *3*(3), 180–185. http://www.cibtech.org/jgee.htm
10. Moghadasi, N., Karimirad, I., & Sheikh, V. (2018). Assessing the Impact of Land use changes and Rangeland and Forest Degradation on Flooding using Watershed Modeling System. In *Natural Hazards* (Vol. 7, Issue 2, pp. 93–106). Islamic Azad University. https://doi.org/10.5772/intechopen.77041
11. Neelofar, M. R., Qadri, H., & Bhat, R. A. (2018). Socio-economic and Health Impacts of Floods in a Trans-Himalayan Ecosystem. *Journal of Geography & Natural Disasters*, *8*(2). https://doi.org/10.4172/2167-0587.1000227
12. Nott, J. (2006). *Extreme events: A Physical Reconstruction and Risk Assessment*. Cambridge University Press. https://www.preventionweb.net/publication/extreme-events-physical-reconstruction-and-risk-assessment

13. Ortega, J. A., Razola, L., & Garzón, G. (2014). Recent human impacts and change in dynamics and morphology of ephemeral rivers. *Natural Hazards and Earth System Sciences*, *14*(3), 713–730. https://doi.org/10.5194/nhess-14-713-2014
14. Vlachos, E. (1995). Socio-Economic Impacts and Consequences of Extreme Floods. *U.S.-Italy Research Workshop on the Hydrometeorology, Impacts and Management of Extreme Floods*, 1–18.
15. Yusuf, M. B., Gabriel, A. T., Bwadi, E. B., Maima, O. A., Ralp, M. M., & Ishaku, A. R. (2023). Socio-Economic Effect of Flooding in Karim-Lamido Local Government Area of Taraba State Using GIS Technique. *African Journal of Social Sciences and Humanities Research*, *6*(1), 49–78. https://doi.org/10.52589/ajsshr-ikzkq6yt

Interdisciplinary Horizons of Changing Trends in Geographical Research

Ankita Raju Khobragade
Ph.D. Research Scholar, Department of Geography, Vasantrao Naik Government Institute of Arts and Social Sciences Nagpur, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur 440023, Maharashtra, India
Email: ankitakhobragade0504@gmail.com

Article DOI Link: https://zenodo.org/records/10559256
DOI: 10.5281/zenodo.10559256

Abstract:

Geography is a multidisciplinary subject touching the spheres of various natural and social sciences. The exchange of newly discovered knowledge in any discipline influences the advancement in other fields. Geographical research possesses all the qualities of scientific inquiry and investigation along with its crux of studying the man-environment relationship. What makes it different is that it involves spatial exploration and inspection in investigating the phenomenon under consideration. This article aims to discuss the explorative nature of geographical research by throwing light on the different influencing and limiting factors.

Keywords: Inquiry, interdisciplinary, influence, knowledge, problem.

Introduction:

Geography is an interdisciplinary field that deals with physical phenomena, physical abstracts as well and human abstracts. Various human activities including economic activities also studied under this field of study. The universe is experimenting with itself and expanding day by day and encouraging us to explore the results of its integration with the help of available resources using our knowledge and understanding. A human being is a social animal, it is our nature that whatever we learn we try to extract and inquire through communication, social interaction, and sharing our knowledge and experiences which ultimately plays an important role in our overall development and growth. This research article is intended to track the journey of geographical research which has been undertaken with the collaboration of other disciplines.

The rationale of the study:

The ideals set aside while writing this research article are as follows:

- To explore the development of geography as a field and its journey in the digital age.
- To analyze the contribution of geography as an interdisciplinary discipline in studying the man-environment relationship.

Review of literature:

In light of the evolution of research techniques and methods in the field of geography, the following research work has been cited:

Butler, Richard (2004), has published an article titled "Geographical research on tourism, recreation and leisure: origins, eras and directions" in which the author concludes that if geographical research is to maintain its distinctiveness, it needs to make explicit its sense of what is important. For that, he requested all the geographers that we should know at least where we have been and where we are now, even if we may not be sure of where we are going next.

CJ Dixon, B Leach (1978), wrote a book titled "Sampling Methods for Geographical Research" in which he predicted that Geographers might perhaps give more attention to choosing sampling time because both time of day and season will affect certain kinds of data.

Cudny, W. (2014), published a research article "Festivals as a subject for geographical research" in which he concluded that the advancement of geographical research on festivals, and developing theories and methods that may be applied to them, will enable the formulation of a research paradigm for the geography of festivals in the future.

David W. Harvey (1968), composed a research article titled "Pattern, Process, and the Scale Problem in Geographical Research" and agreed that Traditional methods of describing patterns, such as regional classification and cartographical representation, have been supplemented by mathematical techniques that allow us to generalize in a variety of ways about spatial patterns.

Garrett, B. L. (2010), composed a research article titled "Videographic geographies: Using digital video for geographic research" in which he concluded that videographic geographies are inspired by a potential to give voice to the weak, creating stronger bonds between researchers and project participants. The article encourages geographers to make the move from analysis to production, citing examples from successful recent projects.

Harrowell, E., Davies, T., & Disney, T. (2017), composed a research article with the title "Making Space for Failure in Geographic Research" in which it has been argued that failure should be recognized as a central component of qualitative geographical field research. It urges to use of failure proactively and provocatively as a powerful resource to improve research practice and outcomes if it is critically examined and shared.

Kwan, M. (2004), composed a research article titled "GIS methods in time-geographic research: geo-computation and geo-visualization of human activity patterns". This paper discusses recent applications of GIS-based geo-computation and three-dimensional (3-D) and agreed that the geo-visualization methods in time-geographic research GIS provides an effective environment for implementing time-geographic constructs and for the future development of operational methods in time-geographic research.

Louis, Renee Pualani (2007), compiled an article "Can You Hear Us Now? Voices from the Margin: Using Indigenous Methodologies in Geographic Research" and through this article, he has raised some key issues about Indigenous methodologies and the role that they can play in future geographical research and urged to carry carried out in a manner

which is respectful and ethically sound.

N Wrigley (1973), has published an article with title "The Use of Percentages in Geographical Research" in which he throws light on the limitations in the common use of percentages as dependent variables in linear regression models are pointed out, and a simple alternative suggested such as logit model.

R. J. Chorley and P. Haggett (1965), compiled the research paper "Trend-Surface Mapping in Geographical Research" which reviews developments in one of the most promising of these techniques, trend-surface mapping, and attempts to assess its significance for, and applications in, the wider field of geographical research.

Research methodology:

Based on the purpose of writing this research article a qualitative type of research methodology has been taken into consideration. Descriptive analysis has been undertaken by throwing light on the historical background spanning millions of years from early civilizations to the encroachment of artificial intelligence into geographical research. Evolution of Geographical Thoughts by Majid Hussain has been a proven milestone in tracking half of the journey of geographical research and the rest has been chased by online available resources via various sites. The requirement of geographical research has been discussed in detail to fulfill the aim of analyzing the contribution of geography as an interdisciplinary subject in studying the man-environment relationship.

Discussion:

Historical background of geography as a discipline:

The discipline of geography has a rich historical background spanning for thousands of years. The nature and scope of the field of geography has been changed over time since its evolution. Here is a quick rundown of its development:

- **Ancient civilization:** the origin of geography as a field can be traced back to the Asian civilizations including the Greeks, Egyptians, and Babylonians because these earlier societies made a significant contribution to the mapping navigation, and understanding of the features of the earth.
- **The contribution of philosophers:** including Thales, Anaximander, and Pythagoras laid the foundations for geographical thoughts. Herodotus often known as the father of history integrated geographical knowledge into his historical writings.
- **Ptolemy:** In the 2^{nd} century AD Claudius Ptolemy's work "Geographia" was a landmark in the historical background of geography as it included maps and coordinates and provided a systematic framework for the understanding of the geography of the earth.
- **The Age of Discovery:** European explorers such as Columbus, Magellan, and Vespucci made a significant advance in the mapping and understanding of the geography of the world during the age of exploration 15 to 17^{th} centuries. the sailing instruments and techniques also developed during this period.

- **The Enlightenment and geographical modernity:** The era of Enlightenment in the 18th century was conducive to the development of modern geography as an academic discipline. Scholars such as Alexander, von Humboldt, and Karl Ritter contributed to the understanding of regional geography and the concept of environmental determinism.
- **19th and 20th centuries:** geography was in the state of evolution with the growth of empirical geography and regional geography. the late 19th and early 20th century saw the emergence of quantitative geography and human geography which emphasized the study of human activity and how it affected the environment, and the 20th century saw the emergence of social geography, which emphasized the study of how people lived and worked.
- **Advancement in technology:** In the 20th century, technological advances such as satellite images, remote sensing, and GIS have changed the way geographers work and the way we understand the world. Such instruments made it possible to collect and analyze the data more accurately and more comprehensively.
- **Geography in the contemporary world:** it has become a diverse and interdisciplinary discipline encompassing physical, human, and ecological issues. geographic studies range from climate change and urban development to geopolitics and cultural landscapes.

  Over the years, geographical research has developed an emphasis on mapping and description to an integrated science, examining how people, places, and the environment interact with each other. In addressing contemporary challenges such as climate change, hazards and disasters, resource management, and urban planning, geography has a crucial role to play. Geographical mapping and techniques have shown a phenomenal change from mere observation to experimental and now analytical and scientific. Wherever we go the GPS tracks our location, it actually can map our journey for the entire day, week, month, or year. It can also be utilized under geographical research, but privacy concerns are also being violated.

Need for geographical research:

Research is something that always tries to explore some kind of fact or some information about a known fact. The researchers always try to explore some new facts or some unexplored facts of the known phenomenon. It always tries to give a solution to the problems.

For example, when all of us were affected by the Covid-19 pandemic. There were huge numbers of scientists who were working in that particular field and they were from different disciplines as few of them were trying to understand the nature of the virus that needs biogeographical know-how, some on the way through which vaccine can be invented that requires knowledge about genetics, and some on kind of strategies can be taken from the perspective of the health that demands planning, some on building up our

infrastructure in a such a way that our regular life would get normalized for that there is requirement of sociology, few of the scientists wanted to know the changing characteristics, trying to know how the nature of the virus changing over the time which needs the knowledge of biology. One at the very early stage scientists started to know why this kind of disease started and for that, it required to know the factors that contributed to its origin and development. Most of the scientists from the discipline of microbiology and immunology are now trying to invent different kinds of medicine, precautionary measures, and vaccines by which we can prevent it. Whichever be the field, one or another way it can be proven that the research tools applied by scientists are almost related to geographical research.

The Importance of Geographical Research:

There are so many geographical facts and geographical events in the real world and we as learners of geography are bound to Geographical research. Researcher while performing geographical research should consider the following enlisted objectives to add academic and social values to the investigation:

1. To Trap the journey of geographical research from observational to experimental
2. To increase, discover, and confirm new geographical knowledge
3. To solve the current problems practically
4. To classify, observe, and summarize geographical facts and events
5. To use observations to control social behavior
6. to determine the welfare of mankind and to make predictions.

While performing the geographical research we have to mention the objective of the research, and without the aim research cannot be defined. Research should need a purpose as it should have an organized inquiry. When we make research, we have to design a methodology for how the research will proceed. In physical science or biological science, they have their laboratories, equipment with particular methodology, and different kinds of formulas with the help of which they progress in their respective field of research. In our social science research, we also have different kinds of methodologies that we have to follow without which no research can be validated. Research must contain an explanation of the unexplained fact. When we finish our research, we must come up with some unknown facts. We have to explore some facts that have not been discovered yet, otherwise, there is no significance in our research, and there is no benefit to society.

When we start researching, at the very beginning we have to put some kind of hypothesis or prepositions. The research work must clarify doubtful prepositions. At the end of the research, we have to clarify the propositions that how far we are right or wrong. With that new facts can be found by exploring new things or some unknown facts of known phenomena and all the significant information or all the characteristics that we have found in geographical research together with the interesting facts that we need to

put forward. So, geographical research possesses all these qualities along with its main feature of studying the relationship between man and the environment, both social and physical.

Nature of geographical research:

Geography is a multidisciplinary subject. A traditional aim of geographical research is to describe the spatial pattern of objects or events and to explain that pattern by way of the causal mechanisms that have generated it[1]. It can be considered as a pure art subject or sometimes as a science, because we have different branches that are more or less related to the pure sciences and sometimes to the social sciences discipline. So, it has a quality because it always follows the methodology of the research design which has been followed up by the researchers of the pure science discipline or also by the social science or humanities discipline.

Their research methods always follow a certain kind of roadmap that we have to follow. First of all, we have to formulate a research question and research hypothesis. Then in our geographical research, a field survey, which involves traveling is very important. People taken to foreign fields or for excursions is not only to go to a new place to explore something new but also if we don't travel to a new place, we cannot explore it. So, traveling and fieldwork is an important part of geographical research. We have to stay in the field and collect information while we are in the field. It is not like putting the questionnaires on a social platform and asking for the information on the phone and then publishing a research paper that can't work in the field of geography. Then we have to use different kinds of instruments: barometers, altimeters theodolite, etc. GPS is also important for data collection and can be done using both qualitative and quantitative methods. Quantitative when we are applying pure statistical analysis and when applying for ethnographic works. Then it gives more emphasis on spatial-based study. In any geographical paper, it is very important and obvious that we should get a particular study area that could be missed in any other social and natural sciences. Starting from Alexander, and Humboldt to Karl Ritter everyone has emphasized traveling, without this our study is incomplete. We have always emphasized selecting a particular area. Our research becomes better or unique because we always try to emphasize a particular phenomenon as a whole and not in isolation.

Classification of Geographical research:

Geographical research can be divided into two broad categories which can be better understood with the help of the following flowchart.

[1] https://sci-hub.se/https://www.jstor.org/stable/621393

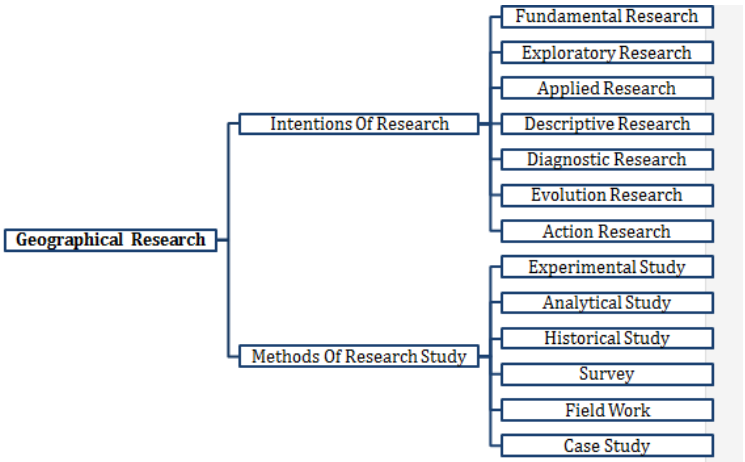


Figure 1: Classification of Geographical research

Source: MS word↔ Insert ↔ Illustrations ↔ Smart chart↔ hierarchy

According to the method of the study:

when a researcher attempts any kind of study, depending on their intention there are a few subcategories of geographical research.

As a researcher, we need to understand the objective of the study. To explore what kind of things, and what kind of research methodology should be applied, the types of research can be subdivided as follows:

- **Fundamental research:** It is attempted out of curiosity, like research on the gravity theory of Newton, Davis's cycle of erosion, etc. It is just about knowing a particular phenomenon that people attempt such kind of research. When there is nothing to solve or explore then it is all about the fundamental research.
- **Applied research**: It is very specific like if someone tries to understand the influence of rural tourism on rural areas means someone tries to understand if there is any negative impact on rural people regarding tourism or if there is a positive impact. So what one has to understand is the problem, the situation what should be done, and what kind of a suggestion can be put that will be applied directly.
- **Exploratory research:** Such a kind of research attempts to explore the facts that are very little known to the people. The general purpose of such kind of research includes generating new ideas, increasing the familiarity of the researcher with a new subject to make a precise formulation of a research problem clarifying the concepts, and gathering new information that adds to the knowledge of the people. For example a research topic on social economic conditions of scheduled caste communities of India. Suppose one has to study this topic so what is the intention? He just needs to understand the situation of the overall scheduled caste community.

It may be possible that researchers may not have any kind of idea about the community so they will get a more in-depth idea about them and make a very precise formulation of the problem. So at the very beginning of the research, we need to ask a question when a research question starts with just what and not any others then the research design will follow exploratory research.

- **Descriptive research:** Suppose there are so many published papers on the same topic then we can't repeat the same because it has already been done. So what we can do is to try to explore the reason behind the problem or a particular situation. So when a research starts with a question of why and not any other then it's become a descriptive research. It will be more specific. It will not try to understand everything holistically, it is very much to the point of the objectives and try to generate new information.
- **Diagnostic study:** The diagnostic study sometimes looks like it is connected with a medication for some disease. It is a kind of exploratory research. It involves an applicable solution that can be directly applied to the people so that the situation can be improved. when we have a research design that can be given a kind of solution to solve the problem known as a diagnostic. so diagnostic research is a kind of applied research. It derives from discovering what is happening and what should be done to try to understand the problem and also put some effective suggestions. For example, health issues of tribal women and some solutions.
- **Evolution studies:** Example assessment of mid-day meal program in the rural villages which has been initiated by the government of India for the benefit of the school-going children. How far are these mid-day meal programs effective in controlling the dropout rate or what are the positive impacts including improved health conditions? If we want to evaluate such a thing. The evaluation is important to understand the success of a particular strategy. When our objective of research contains such a kind of prepositions, we need to perform the evaluation studies.
- **Action research:** It is a type of evaluation study. It is a concurrent evaluation study on an action program that is launched to solve any specific problem.
- **Experimental research:** This is very common in biological and pure science disciplines but in social science, we also have experimental research. Suppose we go to the soil laboratory we can see people collecting different kinds of file samples and try to find different kinds of characteristics of the same. There are various motivations such as productivity development and operational efficiency which are influenced by various variables. It may become necessary to assess the effect of one variable on the others. P for example the effect of hybrid seeds on agriculture productivity.
- **Analytical research:** It generally depends on quantitative methods, mainly statistics. Analytical research can be a part of any kind of research because when we

analyze a whole thing using any quantitative method and statistical application then it is known as analytical research.

- **Historical research:** A study of such kind of research completely dependent on records and other information sources. Based on the foundation built on such resources, a view is constructed depicting the origin and development of an institution movement, or system. Historical research explores the historical facts. Suppose we are trying to understand the administrative system of an institution in India, we have the sources of a book library archives museum. For example, the administrative system of Janapada.

Depending on the method and the kind of Geographical research

- **Survey research:** Suppose like nowadays, geographers are trying to find out the research effect of the COVID-19 pandemic on rural and urban populations. we do not have an opportunity to go there and contact the people of the rural and urban regions. so, what we will do? we will make a Google form and send it to the people through an online platform and take the information from them for collecting a dataset to get an overview of the condition. We are taking a population; we are collecting our sample and then we are researching based on the sample.
- **Case study:** A case study is an in-depth comprehensive study of a person, a society, a group, and the episode, process a situation, program, or community. It is a kind of microscopic study to better understand the existing situation of a particular phenomenon.
- **Field surveys:** it is a data collection technique that involves describing, recording, assembling, analyzing, and interpreting the existing situation by personally visiting the study region under consideration. For example, a population survey during a census.

The difference between a field survey case study and a survey method:

Field surveys and survey methods are very well connected. The thing is that the survey can be done over the phone, Google form, or any other mode of communication. Doesn't require that you have to be on a field like when a cyclone devastated any particular huge area but it is not possible for someone to go to the place just after the implementation of the recovery strategy so one can call up the people whom they know, maybe they have conducted research before and collect a piece of information. In that condition, it can be called a survey but not a field survey. But when a researcher enters the field into a research study area to get a very real-life experience of what is happening and visit people and talk to them face to face interaction and interrogation at that time it becomes a field survey. So, the filled survey is much more authentic scientific, and very reliable.

Limitations:

Geographical research is an indivisible part of other disciplines as in one or

another way it has to be dependent on each other to grab the milestones in their path with the ultimate goal of the welfare of humans and society as a whole. In some way, geographical study helps other disciplines to decide on the research techniques and methodologies. As the universe is evolving and geographical research continues with its interdisciplinary attitude, the sky will be the limit.

Recommendation:

Geographical research will continue to add new dimensions to the basket with the ultimate goal of human welfare, but while performing research care should be taken considering long-term implications. The short-term discovery can resolve pressing issues with valuable suggestions that are urgently required for the society but its long-term impressions could prove equally hazardous. Take the example of digitization. Demonetization in 2016 generated a requirement for digital transaction platforms, and the lockdown during the COVID-19 pandemic boosted and worked as a catalyst for the same. Now, various digital platforms are affecting the lives of individuals in several ways and we even cannot imagine our future without them also becoming techno-addicts. Excess of anything is injurious to the health. Our use of digital platforms has increased exponentially, but the radiation generated through their use, we are not taken into consideration. The long-term impact of this could result in global warming and overall climate change. We are not focusing on the other biotic resources that are getting affected very badly. It is a recommendation that whatever the research, environmental factors should also give a preference so that discovery may prove long-lasting.

Conclusion:

Geography is a social as well as natural science. Geography controls social activities and social behavior and to control social behavior we perform social research. The field of geography is diversifying in itself as it touches corners of various social and natural sciences focusing on man and environment relationships. The scope of the study is evolving by knocking on the doors of recent approaching problems. Scientific and systematic inquiry into them adds up newly discovered knowledge into the discipline and the cycle goes on. Geographical research can be divided into two broad categories according to the moto of the study and depending on the research method for collecting information. The types of research are distinct from each other. Based on knowledge and experience in the field of academic research, a learner can utilize each one of the research types, take assistance from available tangible and intangible resources including artificial intelligence, and give valuable contributions by making it more reliable and trustworthy.

References:

1. “Why Geographic Research || What is Geographic Research.” (…) - Wiktionary, Dynamic Geography, https://youtu.be/9tEEjM0UAh0. Accessed 14 August

2023.Butler, Richard. "Geographical research on tourism, recreation and leisure: origins, eras and directions." Tourism Geographies 6.2 (2004): 143-162.
2. Chorley, Richard John, and Peter Haggett. "Trend-surface mapping in geographical research." Transactions of the Institute of British Geographers (1965): 47-67.
3. Cudny, Waldemar. "Festivals as a subject for geographical research." Geografisk Tidsskrift-Danish Journal of Geography 114.2 (2014): 132-142.
4. Dey, Moumita. “Geographical Research: meaning nature and type.” YouTube, 7 July 2020, https://youtu.be/Lgq1NBdFhoM. Accessed 14 August 2023.
5. Dikshit, Ramesh Dutta. Geographical thought: a contextual history of ideas. PHI Learning Pvt. Ltd., 2018.
6. Dixon, Chris J., and Bridget Leach. "Sampling methods for geographical research." Geo Abstracts, 1978.
7. Garrett, Bradley L. "Videographic geographies: Using digital video for geographic research." Progress in human geography 35.4 (2011): 521-541.
8. Harrowell, Elly, Thom Davies, and Tom Disney. "Making space for failure in geographic research." The Professional Geographer 70.2 (2018): 230-238.
9. Harvey, David W. "Pattern, process, and the scale problem in geographical research." Transactions of the Institute of British Geographers (1968): 71-78.
10. Husain, Majid. Evolution of Geographical Thoughts. Rawat Publications, 2019.
11. Kothari, C. R. Research Methodology: Method and Techniques. Wishwa Prakashan, 1985.
12. Kwan, Mei-Po. "GIS methods in time-geographic research: Geocomputation and geovisualization of human activity patterns." Geografiska Annaler: Series B, Human Geography 86.4 (2004): 267-280.
13. Louis, Renee Pualani. "Can you hear us now? Voices from the margin: Using indigenous methodologies in geographic research." Geographical research 45.2 (2007): 130-139.
14. Nayak, Anoop, and Alex Jeffrey. Geographical thought: An introduction to ideas in human geography. Routledge, 2013.
15. Rana, Lalita. Geographical thought. Concept Publishing Company, 2008.
16. Wrigley, Neil. "The use of percentages in geographical research." Area (1973): 183-186.

[1]https://sci-hub.se/https://www.tandfonline.com/doi/abs/10.1080/1461668042000208453
https://d1wqtxts1xzle7.cloudfront.net/3470289/17-sampling-methods-libre.pdf
https://sci-hub.se/https://www.tandfonline.com/doi/abs/10.1080/00167223.2014.895673
https://sci-hub.se/https://www.jstor.org/stable/621393
https://sci-hub.se/https://journals.sagepub.com/doi/abs/10.1177/0309132510388337
https://scihub.se/https://www.tandfonline.com/doi/full/10.1080/00330124.2017.1347799
https://scihub.se/https://onlinelibrary.wiley.com/doi/abs/10.1111/j.04353684.2004.00167

.x
[1]https://scihub.se/https://onlinelibrary.wiley.com/doi/abs/10.1111/j.17455871.2007.00443.x
[1]https://sci-hub.se/https://www.jstor.org/stable/20000750
[1]https://sci-hub.se/https://www.jstor.org/stable/621689

Land Use/ Land Cover Monitoring in Dharuhera Town of Haryana

Parag Jyoti Kashyap
PhD Research Scholar, Deparment of Geography, Assam University, Assam, India
Email: kashyapparagjyoti@gmail.com
Sachin Kumar
Department of Geography, Central University of Haryana, Adalpur 123029, Haryana, India
Email: sachin9728939001@gmail.com

Article DOI Link: https://zenodo.org/records/10559270
DOI: 10.5281/zenodo.10559270

Abstract:

Land use & land cover, used jointly, refers to the categorization or classification of human activities and natural elements on the landscape across time using accepted scientific and statistical methods of analysis of acceptable source materials. The physical stuff that covers the earth's surface is known as land cover. Land use describes how people use land for socioeconomic purposes; urban and agricultural land uses are two of the mostwell-known high-level kinds of use. Research area is a census town in the state of Haryana is called Dharuhera. Dharuhera Town is located at 28.22N and 76.78E latitude and longitude. This town, which is a part of the Delhi-National Capital Region, is a major industrial hub for the Rewari district in the state of Haryana. This study included both spatial and non-spatial data. The overall area of the town of Dharuhera is 5358823 square meters. Agriculture makes up 30% of the area, followed by residential areas (23.8%), industrial areas (13.3%), water bodies (1.4%), public utilities and facilities (2.4%), plots of land (10.3%), commercial areas (5.7%), public and semipublic areas (1.8%), recreation areas (2.1%), and vacant land (6.3%). Since the liberalization era, industrial activity in Dharuhera Town has caused rapid changes in land use and land cover.

Keywords: LULC, Monitoring, Urbanisation, Dharuhera, Geoinformatics.

Introduction:

Although "land use" and "land cover" appear to be interchangeable and to mean the same thing, there is a difference between the two. Land cover is a term used to describe a physical substance that naturally covers land at the Earth's surface. For instance, among other things, the Earth is covered in water, grass, and trees. The term "land cover" describes how the land is naturally covered. The term "land use" describes whether a particular plot of land is unoccupied or used by people to change the natural environment for a particular purpose, such as for transportation, agriculture, commercial, industrial, or residential uses. Analyzing satellite and aerial photos can also be used to determine the land cover. Managers can better comprehend the geography by using the

data supplied by land cover maps. Maps can aid managers in a number of tasks, including gaining access to urban growth, modeling water quality issues, forecasting and assessing the effects of floods and storm surges, prioritizing regions for conservation initiatives, and comparing changes in land cover with environmental consequences or linkages to socioeconomic changes like population increase. Over the past 200 years, the population of the world has raised six fold, but the urban population has multiplied 100 times, altering the use and cover of the land.

Metropolitan transformation is the effect of urbanization policies. Urbanization is the result of an increase in the population's concentration in urban regions. This phenomenon is characterized by increased urban population growth as well as migration from rural to urban areas. A natural result of urbanization is the expansion of metropolitan edges. During the era of urbanization, agrarian land is continuously modified for metropolitan purposes around the world. As a result, agricultural dependence declines in rural economies, and urbanization rates rise in rural areas. Changes in population, land use, industry, and social development are brought about by urbanization policy.

A crucial type of resource that is put to many different uses is land. The land resource includes biota, water, minerals, and soil. The primary occupations of agriculture and land-related pursuits including fishing, farming, herding, etc., support about 60% of India's population. There is a significant lot of strain on the planet, and demand for land, water, and biological resources are rising as a result of the human population's ongoing, rapid development. The movement that occurs on land is known as land use. The examination of land use and land cover characteristics can be done effectively with the help of remote sensing and geographic information systems (GIS), which also offer tools for planning and modeling land use and land cover.

Statement of the Problem

Due to the rapid growth of the inhabitants and businesses, Dharuhera town is expanding inappropriately. As a result, private land uses are becoming increasingly popular. Numerous hectares of fertile and valuable agricultural land were destroyed as a result of urbanization, industrialization, and sand, stone, and soil quarrying. Recognizing the genuine uncontrolled urban condition and its effects on many significant land uses and covers is crucial in order to start working on Dharuhera's natural state as soon as it is practicable. Despite this, it is challenging to effectively supervise the extensive development of urban regions over rural areas due to the insufficient land checking system.

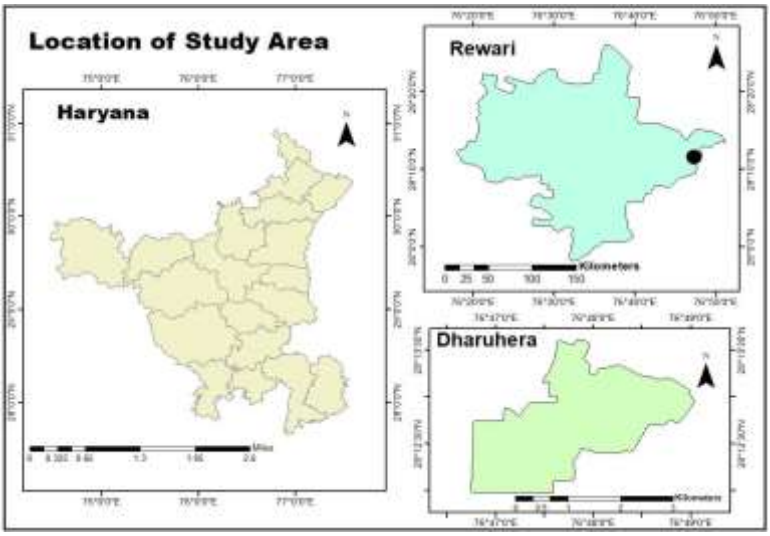
Study Area:

Dharuhera is a census town which is located in the state of Haryana. Dharuhera Town's latitude and longitude are 28.22N and 76.78E, and its elevation is 244m above mean sea level. This town is part of the Delhi-National Capital Region and is a thriving

industrial center for the Haryana-based Rewari district. Town is situated along National Highway 48, formerly known as National Highway 8, which is a crucial section of both the Golden Quadrilateral Road and the Delhi-Mumbai Expressway. The distance between Dharuhera and Gurugram is roughly 40 kilometres, and it takes just an hour to get there from the Indira Gandhi International Airport in New Delhi. Rajasthan's border is touched by it. The towns of Bhiwadi in Rajasthan and Dharuhera in Haryana are essentially one and the same. The two official languages in this area are Hindi and English, with Ahirwati being the most widely spoken local language. Its quick growth has made it a desirable location for businessmen, investors, and real estate developers not just in Delhi NCR or Haryana but throughout all of India. Dharuhera has a population of 30,344 as of the 2011 Indian census. Males make up 54.04 percent of the population overall, and females make up 45.91 percent. The average literacy rate of Dharuhera is 83.18%, which is significantly higher than the literacy rates throughout Haryana and even India, which are 75.55% and 74.05%, respectively. Males are more literate than females are because male literacy rates are 90.21% and 74.92%, respectively. Children under the age of 6 make up 14.60 percent of the population, which is known as the child dependant population. The Schedule Caste makes up 16.10% of the population of Dharuhera. The General and OBC categories make up 83.90% of the population. Additionally, Dharuhera, Haryana, and Delhi NCR do not contain any Schedule Tribes. Hinduism makes up 97.30% of the population of Dharuhera, and other religions including Islam, Jainism, Sikhism, Christianity, and Buddhism make up the remaining 2.70% of the population. Agriculture was practiced on the majority of the Dharuhera's territory. But because it is a part of Delhi-NCR, the land's use is quickly changing to one that is more commercial. The majority of the land has since been developed by real estate investors.

Huge sophisticated manufacturing establishments like Hero Moto Corp. Ltd. (formerly Hero Honda Motors Ltd.) and Jtekt India Ltd. (formerly known as Sona Koyo directing Systems Ltd.) are growing on both sides of
NH48 in Dharuhera. Additionally located in Dharuhera is DELPHI Automotive Systems Pvt. Ltd., a multinational corporation. Venus Engineers, a significant design company, is also located nearby. The largest dairy facility in India, AMUL, as well as the breweries of Carlsberg, Lumax Industries Ltd., Dharuhera Pharmaceutical Pvt. Ltd., Rico Auto Industries Ltd., SehgalS Paper Mills, East India Synthetic, and Indian Oil Corporation are all located nearby. Dharuhera is connected to NH48 and is quite close to the two major cities of New Delhi and Gurugram. It therefore has a great chance of developing into the next major satellite city in the area. The Haryana Urban Development Authority's (HUDA) shortsightedness deprives it of developing sectors and increasingly concentrated private power. In Dharuhera, there are a number of basic public amenities that are inadequate, including good public healthcare, educational institutions, recreation

centers, public spaces, leisure parks, libraries, art galleries, performance venues, stadiums, swimming pools, theaters, multiplexes, and market parking. Although the town is economically expanding, there is a serious lack of town planning, and we discovered inadequate drainage facilities. There is also a difficulty with a proper crematorium or burial place.



igure: Locational Map of Study Area

Objectives: The main aim of the present study is to analyze the land use/land cover of Dharuhera town.

Data Source and Methodology:

In this study, both spatial and non-spatial data were used. Remote sensing and GIS methods were employed to analyze land use and cover in 2021. In the initial stage of the inquiry, ArcGIS 10.7 was used to georeference and digitize the municipal boundaries of Dharuhera town. A satellite image of 2021 that has been georeferenced and acquired from Google Earth is superimposed over the shape file after it has been converted into a KML file. A second mosaic of geotagged images was produced. The third level classification of land use/land cover (LULC) was digitized in a GIS setting and area was approximated based on the NUIS Manual, 2008.

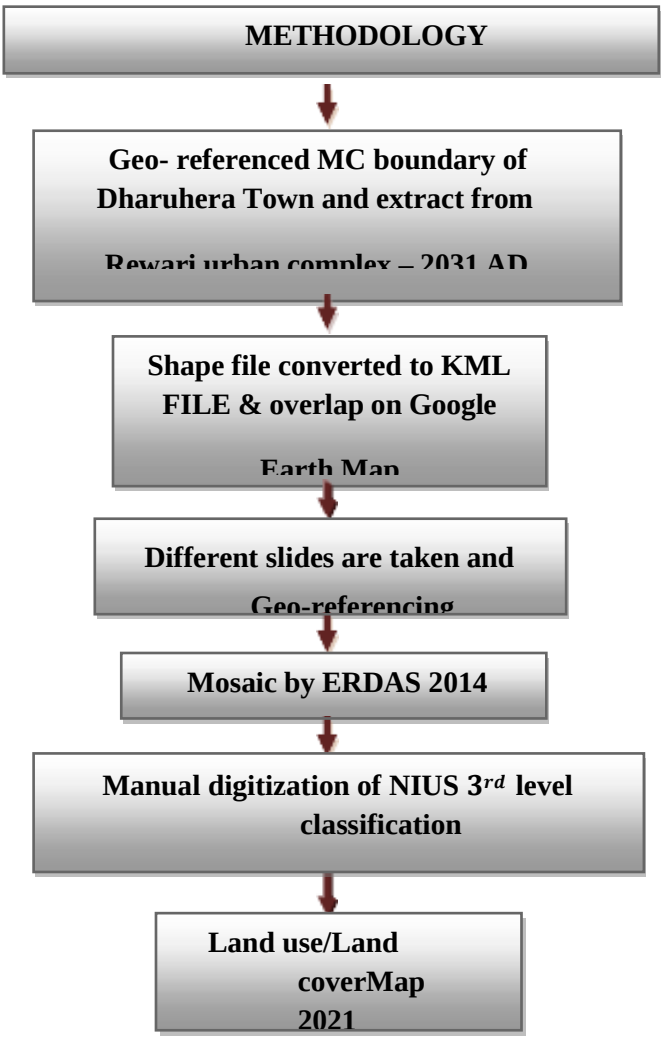

METHODOLOGY
Geo- referenced MC boundary of Dharuhera Town and extract from
Rewari urban complex – 2031 AD
Shape file converted to KML FILE & overlap on Google
Earth Map
Different slides are taken and
Geo-referencing
Mosaic by ERDAS 2014
Manual digitization of NIUS 3rd level classification
Land use/Land coverMap 2021

Figure: Methodological Flow Chart

Result and Discussion:

The categories in table illustrate the various types of land use and cover in 2021. The areas covered by the categories are as follows: agriculture area 1605952 sq. m., residential area 1273189 sq. m., industrial area 712594 sq. m., water bodies 76791 sq. m., public utilities and facility 127650 sq. m., plotted land 550640 sq. m., commercial area 306824 sq. m., public and semipublic area 97434 sq. m., transport and communication 126772 sq.

Table : Land Use/Land Cover category wise area of Dharuhera town 2021.

Land Use/Land Cover Category	Area (sq. m.)	Percentage
Agriculture area	1605952	30.0
Residential area	1273189	23.8
Industrial area	712594	13.3
Water bodies	76791	1.4
Public utilities and Facility	127650	2.4
Plotted land	550640	10.3
Commercial Area	306824	5.7
Public and Semi public Area	97434	1.8
Transportation and communication	126772	2.4
Recreational Area	113451	2.1
Vacant land	337776	6.3
Vegetation Area	29743	0.6
Total area (in Sq. m)	5358823	100

Dharuhera town has a total size of 5358823 square meters. Agriculture makes up 30% of the total area, followed by residential areas (23.8%), industrial areas (13.3%), waterbodies (1.4%), public utilities and facilities (2.4%), plotted land (10.3%), commercial areas (5.7%), public and semipublic (1.8%), transport and communication (2.4%), and recreational areas (4%). Dharuhera Town underwent a substantial change in land use and land cover following the liberalization period, as well as a rise in industrial activity.

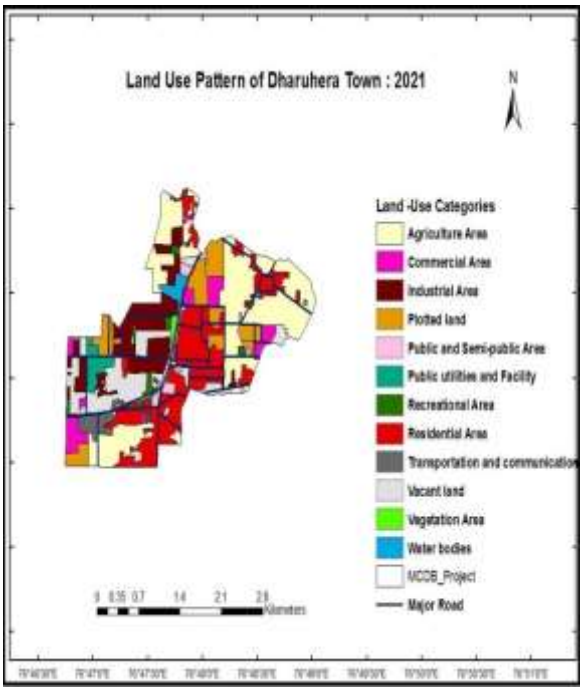


Figure: Land Use Pattern of Dharuhera Town

Conclusions:

The study's objective is to use geoinformatics to monitor Dharuhera Town's land use and land cover. Google earth photos from 2021 were retrieved in order to comprehend the pattern and land use/cover of the town map. According to NUIS's 2008 manual, images are categorized and classified, and the land use categories of agricultural area, residential area, industrial area, water bodies, public utilities and facilities, plotted land, commercial area, public and semi-public area, transportation and communication, recreational area, vacant land, and vegetation land have all been manually digitized. The Dharuhera town's entire area is 5358823 square meters. Agriculture makes up 30% of the total area, while residential areas make up 23.8 percent, industrial areas make up 13.3 percent, water bodies make up 1.4 percent, public utilities and facilities make up 2.4 percent, plots of land make up 10.3 percent, commercial areas make up 5.7 percent, public and semipublic areas make up 1.8 percent, recreation areas make up 2.1 percent, and vacant land makes up 6.3 percent. Land use and land cover have changed quickly in Dharuhera Town since the liberalization era as a result of industrial operations.

References:

1. Adepoju, M. O., Millington, A. C., & Tansey, K. T. (2006, May). Land use/land cover change detection in metropolitan Lagos (Nigeria): 1984–2002. In ASPRS 2006 Annual Conference Reno, Nevada May (pp. 1-5).
2. Alawamy, J. S., Balasundram, S. K., Hanif, A. H. M., & Sung, C. T. B. (2020).

Detecting and Analyzing Land Use and Land Cover Changes in the Region of Al-Jabal Al-Akhdar, Libya Using Time-Series Landsat Data from 1985 to 2017. *Sustainability*, *12*(11), 4490.

3. Jain, M., Dimri, A. P., & Niyogi, D. (2016). Urban sprawl patterns and processes in Delhi from 1977 to 2014 based on remote sensing and spatial metrics approaches. Earth Interactions, 20(14), 1-29.
4. Jiang, J., Friebe, B., & Gill, B. S. (1993). Recent advances in alien gene transfer in wheat. Euphytica, 73, 199-212.
5. KELARESTAGHI, A., AHMADI, H., & Jafari, M. (2006). Land use changes detection and spatial distribution using digital and satellite data, case study: Farim drainage basin, Northern of Iran.
6. Manonmani, R., &Suganya, G. M. D. (2010). Remote sensing and GIS application in change detection study in urban zone using multi temporal satellite. International journal of Geomatics and Geosciences, 1(1), 60.
7. Naikoo, M. W., Rihan, M., &Ishtiaque, M. (2020). Analyses of land use land cover (LULC) change and built-up expansion in the suburb of a metropolitan city: Spatio-temporal analysis of Delhi NCR using landsat datasets. *Journal of Urban Management*, *9*(3), 347-359.
8. Pangelova, B., & Rogan, J. (2006). Land cover and land use change detection and analyses in Plovdiv, Bulgaria, between 1986 and 2000. In Proceedings from Annual Conference of the American Society for Photogrammetry and Remote Sensing.
9. Prakasam, C. (2010). Land use and land cover change detection through remote sensing approach: A case study of Kodaikanal taluk, Tamil nadu. International journal of Geomatics and Geosciences, 1(2), 150.
10. Sreenivasulu and Bhaskar (2010). Change Detection in Landuse and landcover using Remote Sensing and GIS Techniques .*International Journal of Engineering Science and Technology Vol. 2(12), 2010, 7758-7762*
11. Sarma, P. K., Lahkar, B. P., Ghosh, S., Rabha, A., Das, J. P., Nath, N. K., ..& Brahma, N. (2008). Land-use and land-cover change and future implication analysis in Manas National Park, India using multi-temporal satellite data. *Current science*, 223-227.
12. Madan, M. (2005). Urban Land Cover/Land Use Change Detection in National Capital Region (NCR) Delhi: A Study of Faridabad District. *From Pharaohs to Geoinformatics FIG Working Week*.
13. Venkatesan, M., Kumaraswamy, K., & Balaselvakumar, S. (2011). Spatio-Temporal Changes on Land Use/Land Cover in Vaippar Basin, Tamil Nadu Using Geoinformatics Approach.

Migration Dynamics: Unraveling the Interconnected Web of Migration and Sustainable Development Goals

Harpreet Singh
Assistant Professor, Department of Geography, Institute of Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India
Email: harpreetsingh@bhu.ac.in

Article DOI Link: https://zenodo.org/records/10559283
DOI: 10.5281/zenodo.10559283

Abstract:

"Migration dynamics: unraveling the interconnected web of migration and sustainable development goals" offers a comprehensive exploration of the intricate relationship between migration and key Sustainable Development Goals (SDGs). From poverty alleviation and healthcare access to quality education, economic growth, reduced inequality, sustainable urbanization, and justice, this discussion navigates the multifaceted impact of migration across diverse global development objectives. With a focus on diverse academic perspectives and empirical evidence, the abstract underscores the critical need for nuanced policies that recognize and leverage the positive aspects of migration while addressing challenges for a sustainable and inclusive global future. By navigating these interconnected goals, the article aims to provide a concise yet comprehensive understanding of migration's pivotal role in shaping the trajectory of sustainable development.

Keywords: Migration, Sustainable Development Goals, Interconnected

Introduction

In the global pursuit of sustainable development, the intricate relationship between migration and the Sustainable Development Goals (SDGs) emerges as a pivotal yet complex dynamic. This article, titled "Migration dynamics: unraveling the interconnected web of migration and sustainable development goals" embarks on an exploration of how migration interweaves with and influences the diverse facets of the SDGs. The paramount significance of understanding this interplay lies in crafting policies that address the multifaceted challenges and opportunities posed by migration in the context of achieving a sustainable and inclusive world by 2030. Commencing with Sustainable Development Goal 1 (SDG 1) on eradicating poverty, the article delves into migration's role as a poverty alleviation strategy, navigating through remittances and economic opportunities. Transitioning to SDG 3, focusing on health and well-being, it analyzes the impact of migration on healthcare, considering both contributions to the healthcare workforce and challenges faced by the migrants. The exploration extends to SDG 4, dedicated to quality education, examining how migration influences educational

landscapes and the challenges faced by migrant children. Shifting to SDG 8, which centers on decent work and economic growth, the discussion elucidates the intricate relationship between migration and labor markets, economic productivity, and entrepreneurship. As the analysis progresses through SDGs 10, 11, and 16, addressing reduced inequality, sustainable cities and communities, and peace, justice, and strong institutions, respectively, the article unravels the multifaceted dimensions of migration's impact. By traversing these interconnected goals, this article aims to provide a comprehensive understanding of how migration contributes to or challenges the global pursuit of sustainable development. This nuanced exploration sets the stage for informed policy decisions, advocating for an inclusive, rights-based, and sustainable approach to migration within the broader framework of the SDGs.

Data source and methodology: This study adopts a literature review and analysis approach to examine the interplay between migration and Sustainable Development Goals (SDGs). For literature review, comprehensive search across academic databases (PubMed, JSTOR, Google Scholar) and peer-reviewed articles, reports, and publications related to migration and each specific SDG are considered. Articles from academic journals focusing on migration studies, development, and relevant disciplines and reports and publications from international organizations such as the World Bank, WHO, ILO, IOM, and others providing global perspectives on migration and its impact on SDGs are considered.

Objective: To understand the dynamics of migration and analyse the interconnections of migration and SDGs in case of selected SDGs.

Interconnections between Migration and SDGs: Some selected SDGs deals with the migration and migrants. The relations between migration dynamic and SDGs is explained through following point-

1.Sustainable Development Goal 1: Eradicating Poverty

Sustainable Development Goal 1 (SDG 1) seeks to eradicate poverty in all its forms globally by 2030. Migration, a complex and pervasive phenomenon, holds significant implications for achieving this goal. This discussion will delve into the multifaceted relationship between migration and SDG 1, drawing on relevant references and citations to provide a comprehensive understanding.

1.1 Remittances as a Poverty Alleviation Strategy:

Migration often serves as a poverty alleviation tool through remittances. According to Adams and Page (2005), remittances represent a crucial financial resource for many developing nations, directly contributing to poverty reduction by providing families with resources for essential needs such as food, healthcare, and education.

1.2 Economic Opportunities and Income Generation:

Migration offers individuals the opportunity to escape poverty by seeking better economic prospects. Stark and Taylor (1989) highlight the positive relationship between

migration and income, emphasizing how migrants moving to areas with higher wages contribute to poverty reduction.

1.3 Skill Transfer and Human Capital Development:

Migration involves the movement of skilled individuals seeking employment or educational opportunities. According to Beine et al. (2011), this skill transfer enhances human capital, contributing to poverty reduction both in sending and receiving nations.

1.4 Entrepreneurship and Small Business Development:

Migration often fosters entrepreneurship, leading to the creation of small businesses that generate employment opportunities. A study by Fairlie and Lofstrom (2015) underscores the positive correlation between immigrant entrepreneurship and economic development.

1.5 Challenges and Vulnerabilities:

While migration can contribute to poverty reduction, it is crucial to acknowledge challenges. De Haas (2007) discusses potential risks associated with migration, emphasizing the need for policies that protect the rights of migrants and address vulnerabilities.

2. Sustainable Development Goal 3: Ensure Healthy Lives and Promote Well-Being for all at all Ages.

Sustainable Development Goal 3 (SDG 3) aims to ensure healthy lives and promote well-being for all at all ages. Migration, a global phenomenon with far-reaching implications, plays a crucial role in shaping the health and well-being of migrants and the communities they are part of. This discussion will explore various aspects of how migration intersects with SDG 3, drawing on relevant references and citations to provide a comprehensive understanding.

2.1 Access to Healthcare Services:

Migration can influence access to healthcare services for individuals and communities. According to Norredam et al. (2016), migrants may face barriers such as language, cultural differences, and legal restrictions that limit their access to adequate healthcare. Addressing these barriers is essential to ensuring that migrants can enjoy the right to health, as emphasized in SDG 3.

2.2 Impact on Mental Health:

Migration can have implications for the mental health of individuals. Pottie et al. (2017) discuss how migrants may experience stressors related to the migration process, including acculturation challenges, discrimination, and social isolation, which can contribute to mental health disparities.

2.3 Healthcare Workforce Contributions:

Migrants often contribute to the healthcare workforce in destination countries. World Health Organization (2019) emphasizes the importance of recognizing and leveraging the skills of migrant healthcare professionals to address workforce shortages,

thereby promoting good health and well-being.

2.4 Disease Transmission and Surveillance:

Migration patterns can impact the spread of infectious diseases. Gushulak and MacPherson (2004) highlight the need for effective disease surveillance systems that consider the movement of populations to prevent the cross-border transmission of diseases.

3. Sustainable Development Goal 4: Quality Education

Sustainable Development Goal 4 (SDG 4) aspires to ensure inclusive and quality education for all by 2030. Migration, a global phenomenon, has a profound impact on the achievement of this goal. This discussion explores the intricate relationship between migration and SDG 4, drawing on relevant references and citations to provide a comprehensive understanding.

3.1 Cultural Exchange and Knowledge Transfer:

Migration fosters cultural exchange and knowledge transfer, influencing educational landscapes. As articulated by UNESCO (2019), the movement of individuals across borders contributes to a diverse learning environment, enriching educational experiences and promoting a global perspective among students.

3.2 Educational Opportunities for Migrant Children:

Ensuring quality education for migrant children is imperative. According to Suárez-Orozco et al. (2015), addressing the unique needs of migrant children, including language barriers and cultural adaptation, is essential for their successful integration into educational systems.

3.3 Access to Higher Education for Migrants:

Access to higher education is a critical aspect of SDG 4. Findings from a study by Van Hear (2018) emphasize the importance of policies that facilitate equitable access to higher education for migrants, enabling them to contribute to the knowledge economy.

3.4 Bridging Educational Gaps:

Migration often involves the movement of skilled individuals. As highlighted by Özden et al. (2011), migrants can play a role in bridging educational gaps by transferring skills and knowledge, contributing to capacity-building in both sending and receiving countries.

3.5 Educational Challenges in Forced Migration:

Forced migration presents unique educational challenges. According to Save the Children (2019), displaced populations, especially children, often face disruptions in their education. Policies and interventions are crucial to providing quality education for forcibly displaced individuals.

4. Sustainable Development Goal 8: Decent Work and Economic Growth

Sustainable Development Goal 8 (SDG 8) aims to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for

all. Migration plays a pivotal role in shaping the dynamics of labor markets and economic growth. This discussion explores the nuanced relationship between migration and SDG 8, drawing on relevant references and citations to provide a comprehensive understanding.

4.1 Migrant Contributions to Labor Markets:

Migration contributes significantly to labor markets in destination countries. According to Chiquiar and Hanson (2005), migrants often fill gaps in labor markets, especially in sectors facing shortages. Their presence enhances economic productivity, fostering sustained growth.

4.2 Remittances and Economic Development:

Remittances, a product of migrant earnings, contribute to economic growth in countries of origin. As discussed by Ratha et al. (2019), remittances can serve as a stable source of income, positively impacting poverty reduction and creating opportunities for investment.

4.3 Entrepreneurship and Job Creation:

Migrants often engage in entrepreneurial activities, contributing to job creation and economic growth. In their study, Fairlie and Lofstrom (2015) highlight the positive correlation between immigrant entrepreneurship and the growth of small and medium-sized enterprises.

4.4 Addressing Labor Market Gaps:

Migration can help address labor market gaps by providing skilled workers where needed. According to Beine et al. (2011), migrants, especially those with specialized skills, play a crucial role in filling shortages in sectors that require specific expertise.

4.5 Fair Treatment and Labor Rights:

Ensuring decent work for migrants requires attention to their rights and fair treatment. The International Labour Organization (ILO, 2017) emphasizes the importance of protecting migrant workers through policies that guarantee their rights, contributing to decent work and economic growth.

5. Sustainable Development Goal 10: Reduced Inequality

Sustainable Development Goal 10 (SDG 10) seeks to reduce inequality within and among countries. Migration, a global phenomenon, plays a crucial role in shaping patterns of inequality, both positively and negatively. This discussion explores the intricate relationship between migration and SDG 10, drawing on relevant references and citations to provide a comprehensive understanding.

5.1 Economic Inequality and Skill Transfer:

Migration often involves the movement of individuals with diverse skills. Beine et al. (2011) discuss how skilled migration can contribute to reducing global economic inequality by facilitating the transfer of knowledge and expertise from high-income to

low-income countries.

5.2 Income Disparities and Remittances:

Remittances, a significant outcome of migration, can play a role in reducing income inequalities. According to Ratha et al. (2019), remittances act as a stabilizing force, providing financial resources to families in lower-income countries and contributing to poverty reduction.

5.3 Social Inclusion and Cultural Diversity:

Migration contributes to social inclusion and cultural diversity, potentially mitigating social inequalities. The International Organization for Migration (IOM, 2019) highlights how the integration of migrants into host communities fosters diversity, challenging stereotypes and promoting inclusivity.

5.4 Discrimination and Policy Interventions:

Addressing discrimination against migrants is crucial for achieving reduced inequality. According to the Migration Policy Institute (MPI, 2020), policy interventions focusing on anti-discrimination measures are essential for ensuring equal opportunities and treatment for migrants.

5.5 Vulnerability and Protection of Rights:

Migrants, particularly those in irregular situations, can be vulnerable to exploitation and abuse. The International Labour Organization (ILO, 2016) emphasizes the importance of protecting the rights of migrant workers to reduce inequalities and ensure fair treatment.

6. Sustainable Development Goal 11: Sustainable Cities and Communities

Sustainable Development Goal 11 (SDG 11) aims to make cities and human settlements inclusive, safe, resilient, and sustainable. Migration plays a critical role in shaping the dynamics of urbanization and community development. This discussion explores the multifaceted relationship between migration and SDG 11, drawing on relevant references and citations to provide a comprehensive understanding.

6.1 Urbanization and Migration Patterns:

Migration is often linked to urbanization as individuals move from rural to urban areas seeking better opportunities. According to UN-Habitat (2019), understanding migration patterns is essential for sustainable urban development, as it influences population growth, infrastructure demands, and the distribution of resources in cities.

6.2 Diverse Cultural Influences and Social Cohesion:

Migration contributes to cultural diversity in cities, fostering social cohesion. The report by IOM (2017) emphasizes the positive impact of migration on creating vibrant, multicultural urban environments that can enhance social interactions and community resilience.

6.3 Housing Challenges and Inclusive Urban Development:

The influx of migrants to cities often exacerbates housing challenges. De

Sherbinin et al. (2017) argue that inclusive urban development strategies, including affordable housing initiatives, are crucial for accommodating the growing population in a sustainable manner.

6.4 Infrastructure Planning and Service Delivery:

Migration influences the demand for infrastructure and public services in urban areas. Tacoli (2020) underscores the need for effective urban planning that considers the demographic changes associated with migration to ensure sustainable service delivery.

6.5 Economic Contributions and Employment Opportunities:

Migration can contribute to economic growth in cities by bringing a diverse workforce. Haas (2018) discusses the importance of recognizing the economic contributions of migrants and creating policies that ensure their integration into the labor market for sustainable urban development.

7. Sustainable Development Goal 16: Peace, Justice, And Strong Institutions

Sustainable Development Goal 16 (SDG 16) aims to promote peaceful and inclusive societies, ensure access to justice for all, and build effective, accountable, and inclusive institutions at all levels. The relationship between migration and SDG 16 is complex, encompassing issues related to human rights, justice, and governance. This discussion delves into the multifaceted interactions between migration and SDG 16, drawing on relevant references and citations.

7.1 Human Rights Protections for Migrants:

Ensuring the protection of human rights is integral to SDG 16. Pécoud and de Guchteneire (2006) argue for the importance of strong institutions in safeguarding the rights of migrants, emphasizing the need for legal frameworks that address issues like discrimination, exploitation, and violence.

7.2 Combating Human Trafficking and Smuggling:

Migration is often linked to human trafficking and smuggling, posing challenges to peace and security. Gallagher (2010) discusses the role of institutions in combating these crimes, emphasizing the need for international cooperation and strong legal frameworks.

7.3 Rule of Law and Legal Protections:

SDG 16 emphasizes the importance of the rule of law. Guiraudon (2017) explores the relationship between migration and the rule of law, emphasizing the role of legal frameworks and institutions in providing protection and ensuring justice for migrants.

7.4 Governance of Migration Flows:

Effective governance of migration flows is crucial for peace and stability. Papademetriou et al. (2011) argue for the need to strengthen institutional capacity for managing migration, addressing issues such as border management, visa policies, and asylum procedures.

7.5 Social Cohesion and Integration:

Inclusive institutions contribute to social cohesion and integration. The report by the International Organization for Migration (IOM, 2018) emphasizes the importance of governance structures that promote social cohesion by addressing the needs of both migrants and host communities.

Conclusion:

The relationship between migration and SDG 10 underscores the need for comprehensive and inclusive policies. By recognizing the potential for skill transfer, leveraging remittances for poverty reduction, promoting social inclusion, addressing discrimination, and protecting the rights of migrants, the global community can work towards reducing inequality and fostering a more equitable and just world.

The dynamic relationship between migration and SDG 1 requires nuanced policy approaches. Recognizing the positive impacts of remittances, economic opportunities, skill transfer, and entrepreneurship, while addressing challenges and vulnerabilities, can contribute significantly to the global effort to eradicate poverty by leveraging the potential of migration.

In addressing SDG 3, it is imperative to recognize the nuanced relationship between migration and health. By addressing barriers to healthcare access, understanding mental health challenges, leveraging the contributions of migrant healthcare professionals, and implementing effective disease surveillance, policymakers can ensure that migration contributes positively to the well-being of individuals and communities worldwide.

The intersection of migration and SDG 4 requires a holistic approach that addresses challenges and leverages opportunities. By recognizing the importance of cultural exchange, providing inclusive education for migrant children, ensuring access to higher education, and addressing educational challenges in forced migration, the global community can harness the potential of migration to advance the goal of quality education for all.

The interaction between migration and SDG 8 is dynamic, offering both opportunities and challenges. Recognizing the contributions of migrants to labor markets, harnessing remittances for economic development, promoting entrepreneurship, addressing labor market gaps, and ensuring fair treatment are essential components of a comprehensive approach to leveraging migration for sustainable economic growth and decent work for all.

The interplay between migration and SDG 11 requires strategic planning and policy interventions. By understanding migration patterns, embracing cultural diversity, addressing housing challenges, planning infrastructure, and recognizing the economic contributions of migrants, cities can evolve sustainably to become inclusive, resilient, and vibrant communities.

The intersection of migration and SDG 16 underscores the need for robust institutions, legal protections, and international cooperation. By addressing human rights, combating trafficking and smuggling, upholding the rule of law, enhancing governance of migration flows, and promoting social cohesion, institutions can contribute to the peaceful and just integration of migrants into societies, aligning with the principles of SDG 16.

Reference:

1. Adams, R. H., & Page, J. (2005). Do international migration and remittances reduce poverty in developing countries? World Development, 33(10), 1645-1669 Available on https://econpapers.repec.org/article/eeewdevel/v_3a33_3ay_3a2005_3ai_3a10_3ap_3a1645-1669.htm.

2. Stark, O., & Taylor, J. E. (1989). Relative deprivation and international migration. Demography, 26(1), 1-14.

3. Beine, M., Docquier, F., & Rapoport, H. (2011). Measuring international skilled migration: New estimates controlling for age of entry. World Development, 39(5), 678-692. Available on https://discovery.ucl.ac.uk/id/eprint/14288/1/14288.pdf

4. Fairlie, R. W., & Lofstrom, M. (2015). Immigration and Entrepreneurship. In Handbook of the Economics of International Migration (Vol. 1, pp. 877-911). Elsevier. Available on https://people.ucsc.edu/~rfairlie/papers/published/handbook%20chapter%20immigrant%20entrepreneurship%202015.pdf .

5.De Haas, H. (2007). The Myth of Invasion: Irregular Migration from West Africa to the Maghreb and the European Union. IMI Working Papers Series, 1-40. Available on https://heindehaas.files.wordpress.com/2015/05/de-haas-2007-irregular-migration-from-west-africa.pdf

6. Norredam, M., Agyemang, C., Hoejbjerg Hansen, O. K., Petersen, J. H., Byberg, S., & Krasnik, A. (2016). Duration of residence and disease occurrence among refugees and family reunited immigrants: test of the 'healthy migrant effect' hypothesis. Tropical Medicine & International Health, 21(2), 155-163.

7. Pottie, K., Dahal, G., Georgiades, K., Premji, K., Hassan, G., Do, M. T., & Tugwell, P. (2017). Knowledge and attitudes to immigrant and refugee health among medical students at Canadian universities: a cross-sectional survey. BMC Medical Education, 17(1), 1-13.

8. World Health Organization. (2019). Migration of Health Workers: The WHO Code of Practice and the Global Economic Crisis. Geneva: World Health Organization. Available on https://www.migrationpolicy.org/research/migration-health-workers-who-code-practice-and-global-economic-crisis

9. Gushulak, B. D., & MacPherson, D. W. (2004). Globalization of infectious diseases: the impact of migration. Clinical Infectious Diseases, 38(12), 1742-1748. Available on

https://academic.oup.com/cid/article/38/12/1742/304890
10. UNESCO. (2019). Global Education Monitoring Report 2019: Migration, displacement and education - Building bridges, not walls. Paris: UNESCO. https://www.right-to-education.org/resource/global-education-monitoring-report-2019-migration-displacement-and-education-building
11. Suárez-Orozco, C., Suárez-Orozco, M. M., & Todorova, I. (2015). Learning a new land: Immigrant students in American society. Harvard University Press.
12. Van Hear, N. (2018). Refugee higher education: Contexts, challenges and strategies. In Routledge Handbook of Diaspora Studies (pp. 301-318). Routledge.
13. Özden, Ç., Parsons, C. R., Schiff, M., & Walmsley, T. L. (2011). Where on earth is everybody? The evolution of global bilateral migration 1960–2000. The World Bank Economic Review, 25(1), 12-56.
14. Save the Children. (2019). Education in Crisis and Conflict. Retrieved from https://www.savethechildren.org/content/dam/global/reports/education-and-child-protection/education-in-crisis-and-conflict-save-the-children-2019.pdf
15. Chiquiar, D., & Hanson, G. H. (2005). International Migration, Self-Selection, and the Distribution of Wages: Evidence from Mexico and the United States. Journal of Political Economy, 113(2), 239-281.Available on https://ccis.ucsd.edu/_files/wp59.pdf
16. Ratha, D., Sankhayan, A. R., & Kim, S. (2019). Leveraging Migration for Africa: Remittances, Skills, and Investments. World Bank Group. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Leveraging%20Migration-P4-rev-3.31.2011.pdf
17. International Labour Organization (ILO). (2017). General Survey concerning the promotional framework for occupational safety and health Convention, 2006 (No. 187) and the Protocol of 2014 to the Forced Labour Convention, 1930. Report III(1B). International Labour Conference.
18. International Labour Organization (ILO). (2016). General Survey concerning migrant workers (non-seafarers) under the Migration for Employment Convention, 1949 (No. 97), and the Migrant Workers (Supplementary Provisions) Convention, 1975 (No. 143). Report III (1A). International Labour Conference.
19. Migration Policy Institute (MPI). (2020). How to Fix the Global Migration Management System. Retrieved from https://www.migrationpolicy.org/research/how-fix-global-migration-management-system
20. UN-Habitat. (2019). World Cities Report 2020 - The Value of Sustainable Urbanization. United Nations Human Settlements Programme. Available on https://unhabitat.org/world-cities-report-2020-the-value-of-sustainable-urbanization
21. International Organization for Migration (IOM). (2018). Making Mobility Work for Adaptation to Environmental Changes. International Organization for Migration.
22. De Sherbinin, A., Levy, M., Adamo, S., MacManus, K., Yetman, G., Mara, V., ... &

Pistolesi, L. (2017). Migration and risk: net migration in marginal ecosystems and hazardous areas. Environmental Research Letters, 12(5), 055005.
23. Tacoli, C. (2020). Internal migration, urbanization and changing patterns of rural–urban linkages. In The Oxford Handbook of Migration Crises (pp. 271-290). Oxford University Press.
24. Pécoud, A., & de Guchteneire, P. (2006). International Migration, Border Controls and Human Rights: Assessing the Relevance of a Right to Mobility. Journal of Borderlands Studies, 21(1), 69–86 Available on https://documentation.lastradainternational.org/lsidocs/626%20intl_migration_brder_cntrl_070402.pdf .
25. Gallagher, A. T. (2010). The International Law of Human Trafficking. Cambridge University Press. Available on https://www.cambridge.org/core/books/international-law-of-human-trafficking/E74BBE26C60774C6EAA75795A37FDE37
26. Guiraudon, V. (2017). Immigration and Crime Control in Western Europe. Annual Review of Law and Social Science, 13, 417–431.
27. Papademetriou, D. G., Sumption, M., & Somerville, W. (2011). Migration and the Global Recession. Migration Policy Institute.

Using geographic information systems and remote sensing together

Achole Pandurang Bapurao
Assistant professor. Head Dept of Geography. Azad Mahavidayala Ausa Dist. Latur
Email- pbachole@gmail.com

Article DOI Link: https://zenodo.org/records/10559299
DOI: 10.5281/zenodo.10559299

Abstract:

There are numerous opportunities to monitor and manage natural resources at multiple geographical, temporal, and spectral resolutions using remote sensing and geographic information systems (GIS). The specialised skills of an ever-growing variety of picture sources and analysis methods must be understood by natural resource managers immediately. In this review, we gather the different remote sensing and GIS applications that can be used to manage natural resources (agricultural, water, forests, soil, and natural hazards). Natural resource managers can utilise the information to better understand remote sensing experts' work and work together with them to develop and employ remote sensing technology to accomplish monitoring goals.

Keywords: geographic data fusion, image processing, and picture interpretation.

Introduction:

Geographic information science (GISci) is a broad area of study that includes geodesy, traditional cartography, GPS technology, and geographic information systems (GIS). The two main components of GISci are remote sensing and GIS. Although remote sensing and GIS largely evolved separately, there is growing evidence of their interdependence (Aronoff 2005). Today, image processing software frequently offers choices for analysing 'ancillary' geospatial data, and GIS software nearly usually includes tools for displaying and analysing images (Faust 1998). In many publications (Ehlers 1990, Mace 1991, Hinton 1996, Wilkinson 1996), the important advancements made in the "integration" of remote sensing and GIS have been succinctly summarised. Nevertheless, because technological change occurs so quickly, it is imperative to regularly reevaluate the state of the art.

The integration of remote sensing and GIS is the main topic of this chapter. Our notion of integration encompasses the use of one technology to the benefit of the others as well as the joint application of the two technologies for decision-supporting modelling. Simple visualisation considerations, data extraction, database creation, and analysis using "multisource" data will all be covered in the talk. We will stress throughout that while improvements in computing (hardware and software) and GPS technology have undoubtedly aided the development of remote sensing-GIS integration, advancements in theory and analytical techniques, such as the creative application of decision trees, neural networks, and evidential reasoning, have also been crucial. Finally,

we'll give a glimpse into the future and some topics that haven't been sufficiently addressed.

Historical context:

The first examples of integration date back to the early 20th century, despite the fact that the literature on remote sensing-GIS integration is relatively new. Since the 1930s, topographic maps, soil surveys, and land use maps have all been produced using aerial stereoscopic imagery and analogue photogrammetric processing techniques. Of course, important databases in today's geographic information systems are made up of the digitalized versions of these maps. Data for GIS continue to be obtained, updated, and improved through the use of contemporary digital aerial and satellite-borne remote sensing systems, as well as data processing techniques like digital photogrammetry and image categorization.

In a similar vein, those involved in the interpretation of aerial photography have known for at least 80 years that data from other sources, collateral or 'ancillary data' like topographic maps, are essential in such work (see Estes et al. 1983, Jensen 2005). Using numerous data sources and formalised using tools like interpretation keys, photo interpretation necessitates the use of reasoning and logic (Campbell 1978, 2007, Estes et al. 1983). There have been numerous initiatives in recent years to put ideas and techniques for image analysis into practise and enhance them.

In a similar vein, those involved in the interpretation of aerial photography have known for at least 80 years that data from other sources, collateral or 'ancillary data' like topographic maps, are essential in such work (see Estes et al. 1983, Jensen 2005). Using numerous data sources and formalised using tools like interpretation keys, photo interpretation necessitates the use of reasoning and logic (Campbell 1978, 2007, Estes et al. 1983). There have been numerous initiatives in recent years to put ideas and techniques for image analysis into practise and enhance them.

before the advent of digital technology. For instance, improvements in computing power have substantially improved capacities for processing and analysing geospatial data, as well as improvements in digital remote sensing systems and data conversion (such as digitising maps).

Modern methods for integrating GIS and remote sensing:

To assess the current state-of-the-art of remote sensing-GIS integration, Ehlers (1990) established a three-level taxonomy (Table 18.1). The majority of the work we cover in this chapter falls under the categories of first- or second-level integration, but we are moving in the right direction.

GPS must now be added to Ehlers' three-level classification, according to Gao (2002). The GPS, GIS, and remote sensing integration models that he presents emphasise the directionality and sophistication of data flow between the three technologies, and in some ways they parallel Ehlers' classification (i.e., they tend toward'seamless' integration that

makes it easier to perform complex analyses). Despite the fact that GPS will only be briefly discussed in the pages that follow, it should be realised that GPS is a crucial part of modern GIS-remote sensing integration.

A digital image, such as an orthophoto, is overlaid with a cartographic dataset derived from a GIS, such as roads chosen from a digital line graph, to create a merged product that enables an analyst to visualise data from both sources. This is an example of first-level integration of remote sensing and GIS. The two datasets are thought to compliment one another in some way. For instance, if the image is more recent than the GIS data, the analyst may frequently use information extrapolated from the image, using photo interpretation and 'heads-up' digitising, to update the cartography (for example, roads) dataset. Similar to this, one can visualise relationships between land cover (represented on the image) and terrain configuration by "draping" an image over a three-dimensional rendering of topography derived from a digital elevation model (DEM) that has been modified in a GIS. These items can be animated to create digital "fly-overs"; for good examples, visit NASA's Scientific Visualisation Studio at http://svs.gsfc.nasa.gov.

Table 18.1 Levels of remote sensing-GIS integration (modified from Ehlers 1990)

Level of integration	*Principal characteristics*	*Examples of analyses supported*
First-level integration	Achieved via data exchange between separate GIS and image analysis systems	(a) Simultaneous display of GIS (usually vector) data and remotely-sensed (raster) images; (b) Ability to move the results of low-level image processing to the GIS and the results of GIS-based analyses to image-analysis software.
Second-level integration	Permits 'seamless' tandem or combined raster–vector processing facilitated by a common user interface	(a) Capability to incorporate GIS data directly into image processing; (b) Ability to accommodate heterogeneous data input in a coherent manner; (c) Ability to generate simulations combining a GIS and image data with temporal evolution.
Third-level integration	Remote sensing and GIS operate as a single, integrated system – 'telegeoprocessing'	(a) Accommodate raster and vector data in a unified data structure; (b) Facilitate real time analysis using sensor networks and linkages to other technologies.

It is remarkable that even quite straightforward integration of remote sensing and GIS, like the examples mentioned above, can be quite potent. Examples of fresh insights and hypotheses regarding the connections between geographical variables that might be drawn from the visualisation of integrated datasets are discussed below. The integration of remote sensing and GIS, however, frequently involves far more intricate processes than simple visualisation. In the following sections of this chapter, we emphasise second-level and third-level integration, first summarising how remote sensing data are typically used in GIS and the significance of GIS (geospatial) data and analytical techniques in remote sensing. In this conversation, we highlight more advanced integration techniques that are encompassed by terms like "multisource

Data Integration From Remote Sensing Into Gis:

As was already said, aerial photography has long been utilised to produce

analogue geospatial products that, now that they are digital, frequently make up significant portions of GIS databases. The significance of remote sensing in GIS has significantly increased with the development of digital remote sensing instruments and image processing software. The use of orthoimagery as a GIS base layer is just one example of how remote sensing is applied. Other examples include the construction of thematic data on land use and the creation of unique geospatial datasets through the extraction of cartographic features like buildings and roads from imagery.

Orthoimagery as a source of GIS data:

All features in a GIS database need to be placed as precisely as feasible. All data layers must also be geo-referenced to a particular map projection and coordinate system and registered to one another. The frame of reference for positioning, registration, and georeferencing is provided by base maps. Digital orthophotos, which are orthoimages made from aerial photography, or satellite data with high spatial resolution have increasingly been employed as basis layers in recent years (Davis and Wang 2003). In these photos, topography relief and sensor perspective-related spatial displacements have been removed. When compared to base map products like digitalized USGS 7.5 quadrangles (also known as "digital raster graphics"), orthoimages have a number of advantages. For instance, they offer a'realistic' perspective and are typically relatively recent.

Creating theme-based data for a GIS:

Many types of thematic data essential to GIS analysis, such as information on surface elevation and land use and land cover characteristics, come mostly from remote sensing. Aerial and satellite photography is frequently used to update geospatial databases (such as those for highways and hydrography) and to evaluate how the landscape has changed. This volume contains information on the techniques used to produce geospatial data from remote sensing. Here, we just mention a few instances of thematic geographic data that are frequently obtained by remote sensing.

Surface altitude:

In this volume, DEMs (Deng) are utilised extensively in GIS. As was already said, the primary method for mapping surface elevation has been photogrammetry for a very long time. While aerial photography is still frequently utilised in this type of work, satellite imagery, like that obtained by IKONOS and ASTER, is becoming more and more competitive in terms of resolution and accuracy (Hirano et al. 2003). A growing number of active remote sensing techniques are being used to create DEMs, such as airborne laser scanning (ALS) or LIDAR (Hyyppä et al., in this volume) or IFSAR or InSAR (Kellndorfer and McDonald, in this volume). For example, DEMs with less than 30-cm resolution have been created using LIDAR data, which is crucial for GIS-based flood risk assessment and transportation planning (Post et al. 2000). IFSAR offers exceptional cloud penetration, daytime and nighttime operation, and extensive coverage.

IFSAR data from the Shuttle Radar Topography Mission (SRTM) are being utilised to.The majority of the earth's land areas are covered by the DEM GTOPO30, which has a 30 arc-second resolution (Gesch et al. 2001;http://www2.jpl.nasa.gov/srtm/).

Mapping of land use and land cover:

Excellent reviews of the state-of-the-art in classifying multispectral images to map the type and state of land use and land cover may be found in Campbell (2007) and Jensen (2005). For instance, the classification of Landsat data served as the foundation for the U.S. National Land Cover Dataset (NLCD), which is frequently utilised in GIS analysis (Homer et al. 2004; http://www.mrlc.gov/mrlc2k_nlcd.asp). Numerous improvements in mapping land use and land cover result from new analytical techniques built on the fusion of remote sensing and auxiliary GIS data, as discussed later in this chapter.

Biologic-physical phenomena:

A variety of biophysical characteristics, such as surface temperature, imperviousness, water clarity, evapotranspiration, vegetation pigments, biomass, canopy structure and height, leaf area index (LAI), and soil moisture, can be studied using remote sensing (see Wulder 1998, Yang et al. 2003, Courault et al. 2005, and Jensen 2005). Such information is necessary for hydrologic, meteorological, wildfire risk, and crop simulation modelling using GIS (e.g., Keane et al. 2001, Nemani et al. 2002). Global scale biophysical models focusing on carbon dynamics, ecological processes, vegetation productivity, and the dispersion of oceanic phytoplankton are increasingly dependent on biophysical data generated from sensors like MODIS (Huete 2005).

Extraction of features:

To automatically identify and map physical objects (such buildings and roads) from imagery gathered by remote sensing, feature extraction algorithms are used. These processes have been applied to build new data layers or to update or improve the correctness of existing GIS databases (Gruen and Li 1997). The ability to mechanically extract roadways from aerial and satellite photos was assessed by Mena in 2003. In their 2005 report, Shan and Lee described the steps for creating databases of buildings using IKONOS images. Hu et al. (2003) reviewed a variety of integrated remote sensing methods being applied to the extraction of 3-D features in urban settings.

Altered landscape:

Geospatial feature changes can be easily detected and mapped via remote sensing (Lu et al. 2004, Jensen 2005). Today, GIS databases on land use, hydrography, and transportation networks are often updated using aerial and satellite remote sensing (e.g., Jensen et al. 1993, Laliberte et al. 2001). Remote sensing can also be used to evaluate the effects of natural disasters like hurricanes and the advancement of dynamic processes like soil erosion (Lupo et al. 2001, for example). At the local, regional, and global levels, multitemporal data are utilised to track seasonal and interannual landscape

phenomena. As an illustration, Zhang et al. (2006) discussed the use of MODIS data for determining the patterns of vegetation greenness around the world.

Application Of Gis And Geospatial Data To Remote Sensing:

Geospatial datasets that represent phenomena like surface elevation, soils, transportation, hydrography, and land use are typical parts of geographic information systems. Although it has already been mentioned that analyses of aerial and satellite imagery are routinely used to create these datasets, they are typically regarded as "ancillary data" from the perspective of remote sensing. It is commonly acknowledged that supporting information is important for digital picture analysis and photo interpretation (Tso and Mather 2001; Jensen 2005; Campbell 2007). Such work has employed digital elevation models particularly frequently (see Florinsky 1998). According to Jensen (2005), supplementary data may also include the results of GIS analysis, such as topographic slope and aspect (derived from a DEM), soils that have been recoded into hydric and non-hydric classes, or polygons that indicate a road's proximity.

Correction of the geometry and orthorectification:

Due mostly to sensor orientation and terrain relief, remote sensing images show spatial displacements of objects and scale variations (Aronoff 2005; Jensen 2007). To produce a planimetrically accurate (also known as "orthorectified") image, which is an image with characteristics akin to those of a map, such as a constant scale, these displacements must be eliminated. Many image analysis systems include software for making digital orthoimages, but the information needed for rectification, Typically, data must be imported from a GIS, including geodetic control (commonly obtained via GPS) and digital elevation data. An orthoimage, the result of the rectification process, is frequently sent back to the GIS to facilitate further studies. Orthoimages are currently often used as basis maps in GISs to register and georeference other layers, as was mentioned above (Aronoff 2005). Prior to the 'fusion' of several sources of data needed to produce products like perspective views, geometric rectification and registration are necessary (Toutin 2004).

In recent years, orthoimages made from sensors on satellites like IKONOS and Quickbird with fine spatial resolution (1 m) have become more readily available. According to Toutin (2004), the accuracy of digital elevation models with sensor-appropriate horizontal and vertical resolution is crucial for producing high-quality orthoimage products. As was already said, much current work focuses on creating better DEMs. According to Zhou et al. (2004), tall structures can cause mistakes in orthoimages created from DEMs, which typically only depict 'bare earth' terrain. LIDAR, for example, offers to offer a solution for these issues.

Radiometric adjustment:

In order to radiometrically correct digital photographs, digital elevation models

are frequently utilised (Tso and Mather 2001; Aronoff 2005; Jensen 2005). The intricate relationship between land cover, solar illumination angle, atmospheric conditions, and topographic position (slope and aspect) determines the spectral reflectance from the earth's surface. Depending on whether they are located in full sunlight (for example, south facing slopes in the northern hemisphere) or shadow, pixels of the same land cover type in an image might have significantly different brightness levels. Particularly noticeable are these impacts in high relief places. Such artefacts can considerably impair the outcomes of multispectral classification if they are not eliminated.

Topographic normalisation, sometimes known as "terrain correction," is a type of image processing intended to eliminate (or significantly minimise) brightness variance resulting from topographic position. Simple band ratios can occasionally be used to perform topographic normalisation; however, more reliable techniques call for the use of a DEM and slope and aspect produced from a GIS (Gu et al. 1999; Riao et al. 2003). Similar to geometric correction, precise DEMs with a fine enough resolution are essential for terrain correction to be successful.

Categorisation of images:

Although the creation of orthoimagery and topographic normalisation both show a kind of remote sensing-GIS integration, the most advanced forms of integration are currently visible in the categorization and modelling of digital images. Enhancing information extraction and thematic mapping through "data fusion" and "multisource analysis" is the main objective of this effort. Typically, enhancement means increasing the precision and/or category resolution of outputs that are currently produced exclusively through multispectral analysis of digital aerial or satellite imagery. An early, but still very important, analysis of the application of multisource data in image classification was offered by Hutchinson (1982). Campbell (2007), Jensen (2005), Jensen et al. (in this volume), Tso and Mather (2001), and Richards and Jia (1999) all provide excellent, more recent overviews.

There are several different approaches that can be used to classify digital images using multi-source data. All could be seen as efforts to take advantage of the long-recognized value of bringing multiple sources of data (ancillary data and/or multiple types of imagery) to bear on information extraction from images (e.g., through image interpretation) and to partially invoke the reasoning and logic used for the majority of a century in visual interpretation of images (see Jensen 2005, 2007, Campbell 2007). One distinguishing feature of picture interpretation logic is the employment of a systematic approach that moves from "knowns" to "unknowns." And Making use of 'convergence of evidence' and inference to draw conclusions from relationships between various data types (image and auxiliary data). For example, guidelines governing the biogeographic interactions between vegetation zonation, elevation, slope, and aspect in mountainous environments are frequently used in the process of image interpretation (Campbell 1978,

2007, Estes et al. 1983). Here, we look at a number of integration strategies between GIS and remote sensing to enhance information extraction from digital images. These include postclassification sorting, picture stratification, classification modification, and sophisticated techniques for multisource data analysis.

layering of images:

The process of stratification involves splitting an image into areas (or "strata") that are each thought of as being "internally homogeneous." In digital image analysis, one method is to stratify using geospatial data and then classify each stratum independently. For instance, Homer et al. (1997) classified Utah's land cover using Landsat TM data that was stratified using a GIS ecoregions dataset. A different approach was taken by Smith and Fuller (2001), who stratified Landsat TM, SPOT HRV, and IRS images using a digitised map of the boundaries of agricultural field parcels (see also Mason et al. 1988). Sorting land cover types

Later, a per-field or "object-based" (as opposed to per-pixel) method was used to process (for example, crops). The generated maps were superior than a per-pixel categorization created traditionally in terms of accuracy and cleanliness (exhibiting less visual noise). The selection of training data for supervised classification has also been aided by GIS-assisted stratification (e.g., Hutchinson 1982, Ortiz et al. 1997, Mesev 1998).

Alteration of classification:

According to Jensen (2005), the majority of picture categorization relies on parametric supervised or unsupervised statistical approaches. A number of researchers have created techniques for integrating auxiliary data with photography and using it to enhance multispectral classification. Ancillary geographical data have, for instance, occasionally been used to alter prior probabilities (or "weights," which are often considered to be equal) in Bayesian Maximum Likelihood decision rules for the classification of digital images. Prior probabilities can be modified using GIS-derived data to represent expected frequency distributions of informative classes in the image. Mesev (1998), for instance, demonstrated how prior probabilities might be changed using GIS-derived census data (such as dwelling density) to enhance SPOT HRV classification of urban land cover.

Another method involves building a "stacked vector" for each pixel out of digital GIS data (a "logical channel" like elevation) and (multi)spectral image data, effectively increasing the number of channels available for analysis and giving a way to include nonspectral features (Maselli et al. 2000, Jensen 2005). For instance, Wulder et al. (2004) classified the land cover in a hilly region of British Columbia using slope and aspect variables computed in GIS from a DEM and Landsat TM data. After stratifying the image into areas of shadow and nonshadow, they used unsupervised classification of the combined elevation and image data to get the highest mapping accuracies. Slope, when utilised as a logical channel, considerably enhanced Landsat TM, according to

Ricchetti (2000)

Improving class characterization and labelling of spectral classes can also be accomplished by integrating GIS-derived data into picture analysis. Ma et al. (2001), for instance, classified the land cover of Montana in two stages using 33 scenes from Landsat TM using slope and aspect data produced from DEM. They discovered that the strategy enhanced both the robustness of class labelling and the effectiveness of multiscene categorization. Ortiz et al. (1997) used historical cropping pattern data in a GIS to help describe spectral classes established by classification of multidate Landsat TM imagery with a focus on mapping agricultural land cover. Radarsat and Landsat TM imagery combined with census data (such as population density and housing condition) can be used to evaluate urban poverty in radios (census tracts), according to Hall et al. When typical classification techniques fall short in identifying crucial "information classes," some researchers have deliberately employed auxiliary geographical data to supplement a traditional multispectral classification. To make up for the difficulty of a spectrally-based classifier to correctly detect wetlands, Vogelmann et al. (1998) combined National Wetlands Inventory (NWI) data into a Landsat TM classification of the Mid-Atlantic region (see also Lunetta et al. 2003). Brivio et al. (2002) used ERS-1 synthetic aperture radar imagery to show how maps of flooded areas could be improved when picture capture time was not ideal for the occurrence. This dataset was created from a DEM.

Sorting classes after classification:

Long-standing research has shown that certain significant land cover classes and situations may be spectrally indistinguishable when classified using standard techniques, and that some spectral classes may need to be mixed for cartographic reasons. In locations with high topography, for instance, pixels depicting water and a coniferous forest in shadow may unintentionally be assigned to the same spectral class because they have a comparable reflectance. This kind of uncertainty is undoubtedly unacceptable to a user of the manufactured goods. However, it is also frequent to find that pixels of a single land cover type may be assigned to multiple spectral classes since they represent finer variations of that same cover type (for example, ponderosa pine forests on various slopes and perspectives). Given this,Such issues can be solved using geospatial data. This is frequently done by sorting pixels from initial spectral classes into new "informational classes" using decision rules that are implemented through Boolean operations (IFTHENELSE) (Hutchinson 1982). In order to raise categorical resolution of a Land-sat MSS categorization of Olympic National Park from 9 to 21 classes while retaining an accuracy more than 85% for most classes, Cibula and Nyquist (1987) used a DEM and climatic data. In 1998, Vogelmann et al. compiled elevation data (from which they deduced slope, aspect, and shaded relief), city light data from the Defence Meteorological Satellite Programme, historical land use/land cover maps, digital line

graphs, and NWI data.

A land cover classification of the Mid-Atlantic region based on unsupervised Landsat TM data, as well as census data on the population. A land cover classification of the contiguous United States that was originally produced from multitemporal AVHRR NDVI imagery was improved by Brown et al. (1993) using digitalized ecoregions, key land resource areas, climate, and elevation data. To create 189 final informative classes from 70 starting spectrum-temporal classes, an iterative spectral class splitting, merging, and refinement technique was used. Mesev (1998), Driese et al. (2001), and Harris and Ventura (1995) all provide other commendable examples.

Multisource data analysis using advanced techniques:

Several "advanced methods" for classifying images have been created in recent years to supplement and perhaps even expand upon the more conventional statistically based methods. Artificial neural networks (ANN), decision tree classifiers, rule-based or "knowledge-based" classification (sometimes referred to as "expert systems," Lawrence and Wright 2001, Mertikas and Zervakis 2001, Jensen 2005, Jensen et al., in this volume), and evidential reasoning are some of these techniques.Due to the fact that they, unlike conventional classification algorithms, do not make assumptions about the normality of the data distribution and are easily adaptable to heterogeneous data (discrete and continuous, numerical and categorical) that may have varying degrees of accuracy, these approaches to data analysis are well suited to the integration of imagery with non-image (geospatial) data. Additionally, these techniques frequently provide hierarchical, structured procedures that resemble some features of human reasoning. The authors Richards and Jia (1999), Tso and Mather (2001), and Jensen (2005) all offer excellent introductions to cutting-edge techniques for multisource data analysis.

Rule-based classification techniques use a "knowledge base" that contains information, theories, and heuristics unique to a given field (such as the classification of land cover based on IKONOS images and auxiliary data). Classification is governed by rules and criteria that draw from the knowledge base (Jensen 2005). Huang and Jensen (1997) demonstrated that a rule-based approach was superior to both traditional maximum likelihood and unsupervised classification when classifying land cover near a wetland utilising SPOT HRV data along with terrain, soils, and wind fetch data. In order to reach specific classification goals, their study used decision tree classification, a technique that requires systematic binary splitting of explanatory factors, like spectral responses and auxiliary data.

Without considerable a priori expert knowledge, the decision tree method 'automatically' separates key variables from those less relevant in classification (Campbell 2007). For the generation of the 2001 NLCD from multitemporal Landsat TM data and a variety of supplementary data, Homer et al. (2004) used decision tree classification (see http://www.mrlc.gov/mrlc2k_nlcd.asp). Aside from Lawrence and Wright (2001) and

Rogan et al. (2003), further excellent instances of decision tree application in integrated GIS-remote sensing analysis can be found in those papers.

'Evidential reasoning' can also be used to implement rule-based classification (Wilkinson 1996; Mertikas and Zervakis 2001). Many of the benefits of the decision tree approach are included in this process, but it also allows for the use of subjective judgement and gives the user an indication of the risk (or confidence) associated with the decision made for each class. For instance, Franklin et al. (2002) mapped the grizzly bear habitat in Alberta using evidential reasoning. 37 variables that were obtained from DEM, digital vegetation maps, ecological unit maps, and Landsat TM imagery were examined. Findings maps compared to results obtained using maximum likelihood classification in the past, were significantly better.

Another approach to integrating specialised knowledge and auxiliary information with image analysis is artificial neural networks (ANN). According to Civilco (1993), Foody (1995), and Jensen (2005), an ANN is made to mimic human decision-making and reasoning processes, including the construction of rules through training and learning.

However, other researchers have found them to be less effective and more challenging to construct than other methods (Skidmore et al. 1997). Neural networks have occasionally been proven to perform well in comparison to standard classification methods (see Bruzzone et al. 1997 and Mas 2004). Furthermore, even when utilised effectively, it is occasionally challenging to explain how particular categorization conclusions were attained.

Gps, Gis, And Remote Sensing Integration:

It is difficult to overestimate the significance of GPS in modern GIS and remote sensing analysis (see Gao 2002). Image rectification, georeferencing thematic data in a GIS, gathering field data to support image analysis (e.g., for ground truth, calibration, or accuracy assessment), and creation or updating of GIS databases depicting features like roads and utilities are just a few of the analysis steps where GPS may be used. Although the majority of GPS-GIS-remote sensing integration cases still fall under Ehlers' (1990) first and second tiers, there are an increasing number of applications that call for the coexistence of all three technologies. Examples include work in disaster response, mobile mapping, wildlife management, and precision farming (see Gao 2002, Sampson and Delgiudice 2006, Hong et al. 2006).

Future possibilities and research concerns:

We have looked at a wide range of integrations between remote sensing and GIS. Our evaluation is the latest in a long line of periodic evaluations of the state-of-the-art and research challenges (e.g., Ehlers 1990, Mace 1991, Estes and Star 1993, Goodchild 1994, Hinton 1996, Wilkinson 1996, McMaster and Usery 2005). The synergism between the two technologies has been evident for many years. In recent years, theoretical and technical advancements have promoted more "seamless" data

analysis; yet, important, frequently connected challenges still need to be resolved if the full potential of remote sensing and GIS integration is to be realised.

Technological advancements:

The field of geographic information science is one that is constantly evolving. In remote sensing, for instance, the growing use of hyperspectral, microwave, LIDAR, extremely high resolution imagery, and time-series data presents both opportunities and challenges for data fusion and integrated data analysis (e.g., improved characterization of land cover, handling large data volumes, image understanding) (Hepner et al. 2005). Increasingly robust "real time" applications of remote sensing and GIS are being made possible by improvements in internet, wireless, and satellite communications as well as advancements in in-situ sensors (Xue et al. 2002; Aksoy and Aksoy 2004). A growing number of people can now easily access geospatial data through web-based tools like Google Earth and Internet Map Service (IMS) applications, which also allow for the basic integration of imagery and graphics. However, more advanced implementations of web-based integrated geospatial analysis will need to address issues with metadata standards, data transmission formats, client/server computation, and communication protocols.

Data accessibility and properties:

More people than ever have access to geospatial datasets, and they are more affordable than before. A growing number of web-based search tools and portals, such as http://gos2.geodata.gov/wps/portal/gos and http://nationalmap.gov/, offer more effective ways to find and access data. However, there are still problems with recognising and describing varied, and frequently ambiguous, data quality (such as spatial and category resolution, positional and attribute accuracy) (Davis et al. 1991, Lunetta et al. 1991, Florinsky 1998, Shi et al. 2005; Zhu 2005). Additionally, challenges are still being caused by long-standing variations in geospatial data representation. Raster images commonly need to be combined with vector GIS data, and outputs in vector format are frequently needed (for use in GIS-based analysis). The long-standing division between raster and vector data structures (and "field" and "object" models of the world), as well as the challenges of integrating data represented in these disparate modes, remain problematic (Goodchild 1994; Blaschke et al. 2000), despite efforts to develop new (for example, object-oriented) geospatial data models. It has recently been recognised that better multisource data analysis may depend on creating ontologies that enable data integration (Fonseca et al. 2002).

Analysis techniques:

Some 'advanced methods' of integrated data analysis that exhibit significant potential have been discussed above. However, creating the knowledge bases and creating the rules necessary to apply the majority of such systems are challenging. Although many tasks still need to be completed, several researchers have investigated the

application of data mining and machine learning techniques (Huang and Jensen 1997; Yuan et al. 2005). Research that aims to better understand the human aspects of geospatial/image data analysis, such as an explanation of how people interpret images, must be the foundation of such initiatives (Argialas and Harlow 1990). Using fuzzy notions to, for instance, decrease the artefacts of merging data with different forms requires more development. (e.g., to better represent indeterminate boundaries such as gradients) and to improve multisource classification (Goodchild 1994, Jensen 2005). It is clear, too, that we require much better methods for tracking and characterizing errors generated when multisource data having different inherent scales, resolutions and accuracies are fused for analysis (Ehlers and Wenzhong 1996, Wilkinson 1996, Shi et al. 2005).

Environmental modeling in a fully-integrated data processing environment:

The synergism between remote sensing and GIS is enhanced when these technologies are used in concert with ancillary technologies such as GPS and in-situ sensor networks and advanced telecommuncations. 'Telegeoprocessing' in concept embodies the third- level integration envisioned by Ehlers (1990). Although, as noted above, many challenges remain, significant progress has been made toward this goal. Now we see increasing efforts to take the next step − full integration of telegeoprocessing with models designed to address specific issues and support decision-making. Keane et al. (2001), for example, review progress toward integration of remote sensing, GIS, and biophysical models for wildland fire risk assessment and management. Nemani et al. (2002) describe the Terrestrial Observation and Prediction System, a prototype endeavor that integrates satellite-derived data (e.g., MODIS LAI), ancillary geospatial data (e.g., DEM, soils), surface weather observations, and a terrestrial ecosystem model to forecast biophysical conditions such as soil moisture in near-real time. In applications of this type, integration of GIS and remote sensing is important in virtually the entire process from data capture and assimilation to database development, data analysis and delivery of information to users. As we approach realization of the potential of telegeoprocessing, the need to develop and test real-world applications will be a continuing priority.

Education:

Finally, but certainly not least important, we believe that advances in integration of remote sensing and GIS call for periodic re-examination of how these technologies are taught (Lauer et al. 1991). At introductory and intermediate levels, instruction in remote sensing and GIS will likely continue to be offered in separate courses as has been traditional. However, the synergism between the two technologies is now quite evident, and technical means to integrate data are rapidly expanding. Next-generation geospatial scientists need to be conversant with both the intellectual foundations and the technical methods by which integrated data analysis can be conducted. We suggest that this might

best be accomplished through capstone courses, practicums or seminars in which students are compelled to consider remote sensing−GIS integration and telegeoprocessing

References:

1. Zhu, A-X. , 2005. Research issues on uncertainty in geographic data and GIS-based analysis. In: R. B. McMaster, ed. and E. L. Usery (eds), A Research Agenda for Geographic Information Science. CRC Press, Boca Raton, FL. Chapter 7: pp. 197–223.
2. Xue, Y. , A. P. Cracknell , and H. D. Guo Telegeo-processing: the integration of remote sensing, geographic information system (GIS), global positioning system (GPS) and telecommunication. International Journal of Remote Sensing vol. 23 no. (9) pp. 1851–1893. 2002.
3. The authors are Laliberte, A. S., Johnson, D. E., Harris, N. R., and Casady, G. Geographic Information Systems (GIS) and remote sensing are used for stream change studies. Journal of Range Management, volume 54, 2001, pages A22–A50.
4. R. S. Lunetta, R. G. Congalton, L. K. Fenstermaker, J. R. Jensen, K. C. McGwire, and L. R. Tinney. Data integration in remote sensing and geographic information systems: error sources and research challenges. Photogrammetric Engineering and Remote Sensing, vol. 57, no. 6 (June 1991), pp. 677-687.
5. R. S. Lunetta, R. G. Congalton, L. K. Fenstermaker, J. R. Jensen, K. C. McGwire, and L. R. Tinney. Data integration in remote sensing and geographic information systems: error sources and research challenges. Photogrammetric Engineering and Remote Sensing, vol. 57, no. 6 (June 1991), pp. 677-687.

Forced Slum Eviction: A Silent Catastrophe in Indian Metropolitan Cities

Satarupa Dasgupta
Assistant Professor, Department of Geography, Nagar College, District Murshidabad, PIN-742159, West Bengal, India
Email: dgswati77@yahoo.co.in

Article DOI Link: https://zenodo.org/records/10559326
DOI- 10.5281/zenodo.10559326

Abstract:

Slum eviction has been a significant issue in the metropolitan cities of India from 2011 to 2021. Rapid urbanization and population growth have led to the creation of slums in these cities, where a large number of people live in inadequate and unsanitary conditions. The first wave of slum evictions occurred in the last decade of twentieth century with cities achieving global status. In subsequent years, slum evictions continued to take place in various metropolitan cities, driven by government policies aimed at beautifying and transforming urban landscapes. Several cities implemented slum rehabilitation schemes, offering alternative housing to evicted residents. However, the lack of transparency, corruption, and delays in the implementation of these schemes left many without a proper home, exacerbating their vulnerability. The findings reveal significant variations in eviction patterns among different metropolitan cities, reflecting the complex urban dynamics and policy landscapes in India. Understanding the trends and implications of slum evictions in Indian metropolitan cities is crucial for policymakers, urban planners, and civil society organizations working to ensure equitable urban development. The research underscores the need for inclusive urban policies that balance development goals with the protection of vulnerable slum communities, ultimately aiming for more sustainable and just urban environments.

Keywords: slum eviction, urbanization, metropolitan cities, urban policy, urban development.

Introduction:

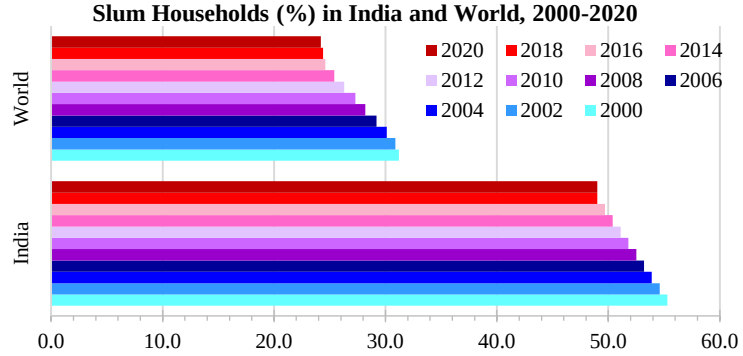
Background of the study:

A slum is *an exceedingly populated urban residential area comprising of densely crowded housing units of poor quality and frequently linked with poverty*. It is widely used to describe people living in substandard conditions. Urbanisation has become synonymous with slum formation in cities of developing countries (UNHABITAT, 2010). The rapid pace of urbanization has shaped slums as dumping ground for the migrating population who are incompetent to afford quality housing. About 24.2 % of the global urban population are living in urban slums households (UNHABITAT, 2022). These slums are an indispensable part of the cities and towns contributing to their phenomenal growth. There are broadly two types of slums, namely

formal slums and informal slums based on their legal ownership of land. An informal slum (often considered illegal) is frequently defined by- insecure unhealthy homes (e.g. dearth of windows, stained floor, leaky walls and roofs), overcrowded homes, limited or no access to basic services like potable water, toilets, electricity, unstable homes with weak structures (often puffed away or wrecked during storms and earthquakes) and no secure land tenure (i.e. the land rights to live there). Collective factors such as accelerated rural-urban migration, unplanned urban policies, locational choice, poor governance have led to the growth of informal slums in the third world Countries. It is habitually these informal slums that are always at risk and vulnerable to forced eviction anytime. Studies have revealed that the choice of shelter/ housing for the urban poor is a complex analysis. Cheap and easy accessibility of housing in public land in proximity to their job location is often selected although there is no security of tenure in urban areas. Inadvertently theses are illegitimate owing to any mixture of low standard of services, infrastructure; breaches of land; deficiency of planning and construction permits; or the irregular nature of the land.

The figure 1 illustrates that the proportion of urban population living in slum

Figure No. 1: Proportion of Urban Population living in Slum Households (%) in India and World, 2000-2020



households has decreased in both India and the world over the past 20 years. In India, the proportion of urban population living in slum households decreased from 55.3% in 2000 to 49.0% in 2020 (UNHABITAT, 2020). In the world, the proportion of urban population living in slum households decreased from 31.2% in 2000 to 24.2% in 2020 (UNHABITAT, 2020). The decrease in the proportion of urban population living in slum households has been more pronounced in India than in the world. This might be due to the fact that the government of India has implemented more aggressive policies to either improve slum infrastructure and provide better housing options for people living in slums

or slum eviction.

Table 1. Summary of forced slum eviction in India, 2017-21

Year	Total reported cases of slum eviction	No of slum houses demolished	Slum people forcibly evicted	Rate of houses demolished/ day	Rate of persons evicted/ day	Rate of homes demolished/ hour	Rate of persons evicted/ hour	Rate of slum eviction cases/ month	Time interval for each slum eviction	Cause of slum eviction				
										City beautification (%)	Development projects (%)	Environmental project (%)	Disaster management (%)	Others (%)
2017	213	53,791	2,58,196	147	707	6	30	18	1/ 41 hours	46	25	14	8	7
2018	218	41,734	2,02,233	114	554	5	23	18	1/ 40 hours	47	26	20	7	-----
2019	146	22,247	1,07,625	61	295	3	12	12	1/ 60 hours	43	24	16	9	8
2020	147	36,812	1,73,333	101	475	4	20	12	1/ 60 hours	19	25	49	2	5
2021	158	36,486	2,07,106	100	567	4	24	13	1/ 55 hours	14	27	57	1.6	0.4
Total	882	1,91,070	9,48,493	105	520	4	22	15	1/ 50 hours	33.8	25.4	31.2	5.52	4.08

Data Source: HLRN, 2018, 2019, 2020, 2021, 2022

As India evolves through the rapid phase of urbanization, slums and urban poverty had intensified to a critical point. As per the High-Powered Expert Committee 2011, direct migration to urban areas accounts for 20 to 25 % of the increase in urban population (NBO, 2015). Almost 17.7 million people lived in slums in the metropolitan cities, which was about 33.8 % of the total slum population in the country reported by the 2001 Census (NBO, 2012). As per 2011 Census, around 31.2 % of the population of India, that is approximately 377 million people lived in urban areas and this is projected to add about 900 million more by 2050 (KPMG, 2012). About 65.49 million inhabitants living

in 13.9 million slum households have been enumerated in 2613 cities/ towns based on Census 2011 (NBO, 2015). The slum population calculated was 22.4 % of the total population of the slum reporting cities/ towns and 17.4 % of total urban population of all the States and UTs as per Census 2011 (NBO, 2015). The national urban housing shortage was estimated at 26.53 million during the Eleventh Five-Year Plan (2007-2012), which decreased to 18.78 million according to a Report of the Technical Group on Urban Housing Shortage during 2012-17 (NBO, 2015). Almost 95 % of this deficiency or 17.96 million dwelling units' shortage were for the Economically Weaker Sections (EWS) and Low-Income Groups (KPMG, 2012).

As the slums grow in number and size, forced slum eviction follows in many instances. To regulate the growth of many of these informal settlements, different administrations have refuted with different policies, from slum evictions and prohibition of growth of slums to provision of alternate land and social housing. Many of the informal slums are spatially, socially and economically excluded from the prospects of the wider urban environment. They are often discriminated and marginalised and are prone to the exposed unhygienic slum environment.

Forced Eviction: An Emblematic global trend

Forced slum eviction have become a predominant global trend in third world cities. It is normally defined as the permanent or temporary demolition of the homes which they inhabit, without the provision of civic amenities, appropriate forms of legal or other protection against their will. Often slum-dwellers are not recognised as residents of the city and are at permanent risk of eviction (UNHABITAT, 2010). Since their inception, Indian metro cities have witnessed a reorganization of urban space. Subsequently, Smart City projects, Slum free city notions, infrastructure expansion, urban renewal projects, and "beautification" operations, have caused in forced eviction of slums.

During the last decade of the twentieth century, urban India have experienced a shift in the city-based economic development in the post liberalisation period for selective big cities along with urban real estate growth, expansion, opening up of locked urban space and reinvesting and creation of new employment opportunities. These cities in spite of being generators of wealth have attracted rural migrants affecting the city's demographic scenario. In 2005 the controversial Jawaharlal Nehru National Urban Renewal Mission Programme was launched which bestowed pro-poor statements like provision of urban poor basic services and tenurial rights, but slum demolition converted into the most sought after or favoured resolutions by the policymakers in the name of urban renewal programme.

Table No. 1. reveals the characteristics of forced eviction in India. Between 2017 and 2021, India witnessed a high rate of slum eviction, with 882 reported cases, 9,48,493 people affected and 1,91,070 houses being demolished (HLRN, 2022). This

indicates a lack of respect for the rights and dignity of the urban poor, who are often downgraded and victimized against by the authorities and the society. The main motive for slum eviction was city beautification (33.8%), which shows that the government prioritized beautification and superficial aspects over the basic needs and welfare of the slum dwellers. Development projects (25.4%) and environmental projects (31.2%) were also common reasons of slum eviction, but they often lacked proper consultation, compensation and rehabilitation for the affected communities. The year 2020 saw a drastic increase in slum eviction due to the implementation of environmental projects (49%), which could be related to the COVID-19 pandemic and its imprint on public health and sanitation (HLRN, 2022). However, this also exposed the vulnerability and insecurity of the slum dwellers, who faced eviction without adequate protection or alternative provisions. The year 2021 saw a decrease in slum eviction due to city beautification (14%) and other causes (0.4%), which could be a sign of some positive changes in the government's policies and attitudes towards the urban poor. However, this was offset by an increase in slum eviction due to environmental projects (57%) and development projects (27%), which still posed a serious threat to the livelihoods and rights of the slum dwellers (HLRN, 2022).

The data illustrates that during 2017-21 on an average, 105 houses and 520 people were evicted from slums every day, and 4 houses and 22 people were evicted every hour (Table No.1). Slum eviction happened about 15 times every month, and it took about 50 hours between each eviction. The year 2017 had the most houses and people evicted from slums every day and every hour, while the year 2019 had the least (Table No.1). The year 2017 also had the most slum eviction cases every month, while the year 2019 and 2020 had the least. The year 2017 had the shortest time interval between each slum eviction, while the year 2019 and 2020 had the longest. The year 2017 had the highest rates of houses demolished and persons evicted per day and per hour, as well as the highest rate of slum eviction cases per month and the lowest time interval for each slum eviction. This suggests that the year 2017 was the worst year for the slum dwellers in terms of eviction (Table No. 1).

The year 2019 had the lowest rates of houses demolished and persons evicted per day and per hour, as well as the lowest rate of slum eviction cases per month and the highest time interval for each slum eviction. This suggests that the year 2019 was the best year for the slum dwellers in terms of eviction (Table No. 1).

As stated by HLRN (2020), more than 40 lakh people in India are homeless and almost 7.5 crore people are living in informal settlements.

Objectives of the study:

The objectives of this paper are as follows:

1. To examine the trend and explanations behind slum eviction in metropolitan cities of India.

2. To explore the efficiency and fairness of government policies and strategies for slum eviction in metropolitan cities.
3. To recognize the challenges and constraints faced during the process of slum eviction and relocation in metropolitan cities.
4. To suggest recommendations and alternative solutions for addressing the issue of slum eviction in a sustainable and inclusive manner.
5. To highlight case studies and examples of successful interventions and initiatives aimed at mitigating the negative impacts of slum eviction in metropolitan cities.
6. To contribute to the existing literature and knowledge base on slum eviction in India, and to inform future policy-making and decision-making processes in this area.

Methodology:

This research has used a secondary data analysis approach to explore the phenomenon of forced slum eviction in the metropolitan cities of India. Since the latest census data for 2021 is yet to be published the author takes into consideration the 52 metropolitan cities of India as of census 2011 for the present study.

Although forced slum eviction has been an ongoing process witnessed in urban and rural India, the author would like to focus on the million cities of India in this paper for a period of 11-years starting from 2011 to 2021.

Existing slum eviction data in metropolitan cities of India have been collected from reports published by the *Housing and Land Rights Network (HLRN)* in the absence of any published data on urban slum eviction by the central or state governments. HLRN, through its 'National Eviction and Displacement Observatory,' has endeavoured to document the different evictions taking place in India since 2010 to 2021. The author has extracted the slum eviction data of metropolitan cities from 2011 to 2021 from the various reports of Housing and Land Rights Network (HLRN).

The researcher tried to synthesize and analyse the secondary data sets to gain insights into the causes, consequences, and patterns of forced slum evictions in metropolitan cities. A comprehensive review of academic literature, official reports, policy documents and publications from government agencies, non-governmental organizations (NGOs), and international organizations and media sources related to forced slum evictions in metropolitan cities have been conducted to provide an initial understanding of the issue and identify key themes, trends, and knowledge gaps. These sources offered valuable insights into the scale and nature of slum evictions, policy frameworks, and social impacts. News articles, press releases, and media coverage on forced slum evictions from reputable news sources were accessed offering real-time accounts and perspectives on specific eviction events and its implications. Research articles, and case studies focusing on slum evictions were referred to study the empirical evidence, theoretical frameworks, and contextual understanding to the research topic.

Ethical considerations were taken into account by ensuring proper citation and attribution

of sources to adhere to the principle of academic integrity and responsible use of secondary data.

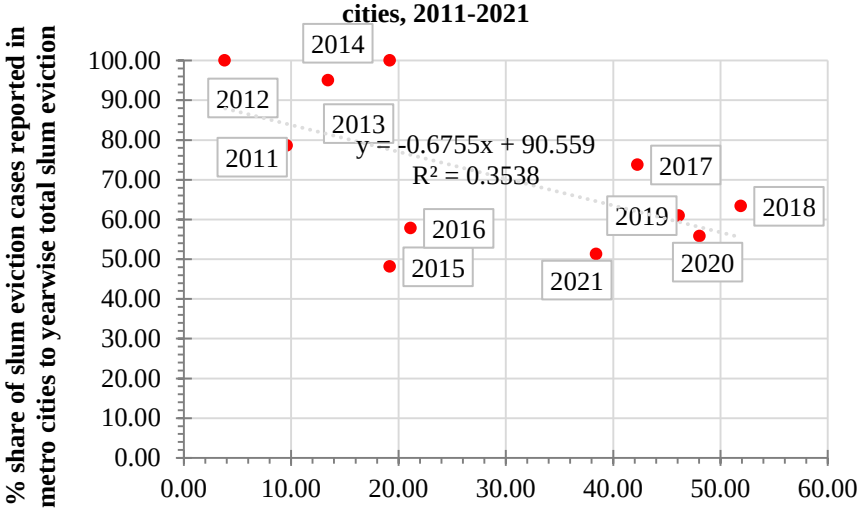
The study's findings might be constrained by the availability, reliability, and completeness of the secondary data. By leveraging existing information from various sources, this research aims to contribute valuable insights into the nature, extent, and implications of forced evictions, informing policy discussions and advocacy efforts to address this critical issue.

Research Findings:

Temporal distribution of slum eviction in metropolitan cities during 2011-2021:

1. ***Variability in Metropolitan Cities with slum eviction:*** The share of metropolitan cities with slum eviction cases varies from 2011 to 2021, ranging from as low as 3.85% in 2012 to as high as 51.92 % in 2018. This indicates that the extent of slum eviction cases in metropolitan cities is unpredictable and has seen significant oscillations (Figure No. 2).
2. ***Variability in share of slum eviction cases in Metro Cities:*** The percentage share of slum eviction cases in metro cities to year wise total slum eviction also displays changeability, ranging from 55.78 % in 2020 to 100 % in some years (2012, 2014). This hint at years where the majority of slum eviction cases are focused in metro cities, while in other years, the distribution is more diverse. Occurring in other urban and rural areas (Figure No.2).
3. ***Inverse affiliation in some years:*** In some years (e.g., 2012, 2014), when the percentage share of slum eviction cases in metro cities is 100%, the percentage of metropolitan cities with slum eviction is relatively lower (3.85% and 19.23% respectively). There appears to be an inverse relationship in these years, signifying that a lesser number of metropolitan cities were accountable for a higher share of slum eviction cases (Figure No. 2).
4. ***Increased Metropolitan slum eviction in recent years:*** There is a perceptible increase in the percentage of metropolitan cities with slum eviction during 2017-2021. This might indicate an escalation of slum eviction efforts in metropolitan areas during these years (Figure No.2).

Figure No. 2: Proportion of slum eviction cases in metro cities, 2011-2021



Data Source: HLRN, 2022

In summary, the trend in the data shows that slum eviction activities in metropolitan cities are not constant but rather exhibit fluctuations over the years. The relationship between the two variables is not straightforward and may be influenced by various factors, including urban development policies, socioeconomic conditions, and local governance.

Also, the average percentage of reported slum eviction cases in metropolitan cities calculated for the five-year period (2017-2021) was 61.45%, which means that more than half of the slum eviction cases in India occurred in metropolitan cities. This indicates that the slum dwellers in metropolitan cities faced a higher risk of eviction than those in other areas.

City wise slum eviction scenario during 11-year period (2011-2021):

There are multiple cities with relatively lower shares of slum eviction cases, each contributing less than 1% to the total during the mentioned period. Some cities listed in the data, including Asansol, Durg-Bhilainagar, Jodhpur, Kannur, Kanpur, Kochi, Kollam, Kozhikode, Malappuram, Meerut, Thiruvananthapuram, Thrissur, and Vasai Virar City, have reported zero slum eviction cases during this period (Figure No.3).

The data indicates that slum eviction activities have been more concentrated in certain cities, such as Delhi, Mumbai, Chennai, and Ahmedabad, compared to others (Figure No.3). The varying shares of slum eviction cases among cities could be influenced by factors such as urbanization trends, development policies, and population dynamics.

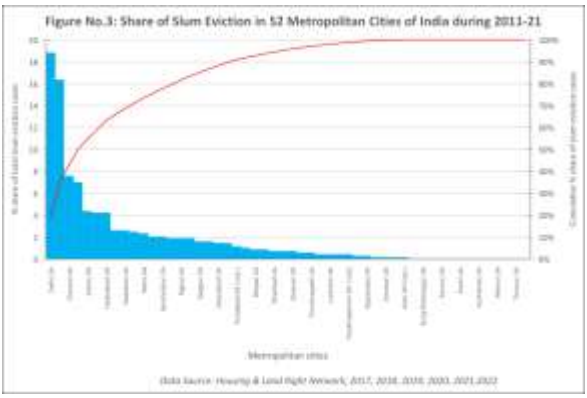
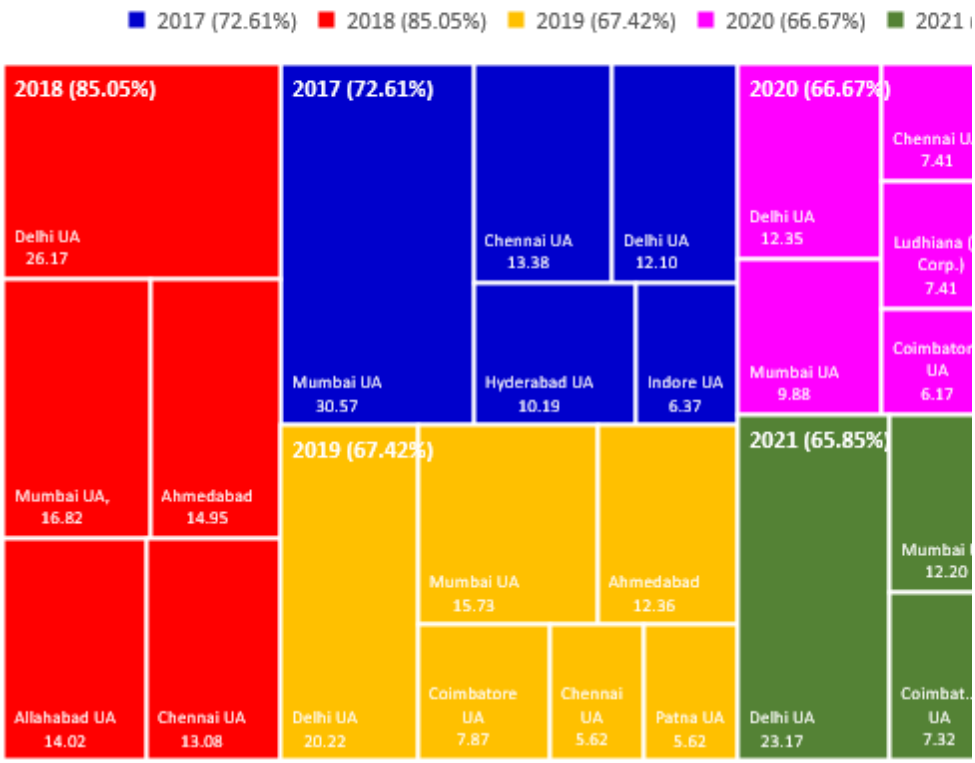


Figure No. 4: Top five ranked metropolitan cities with respect to highest share of s cases in the respective year, 2017-21

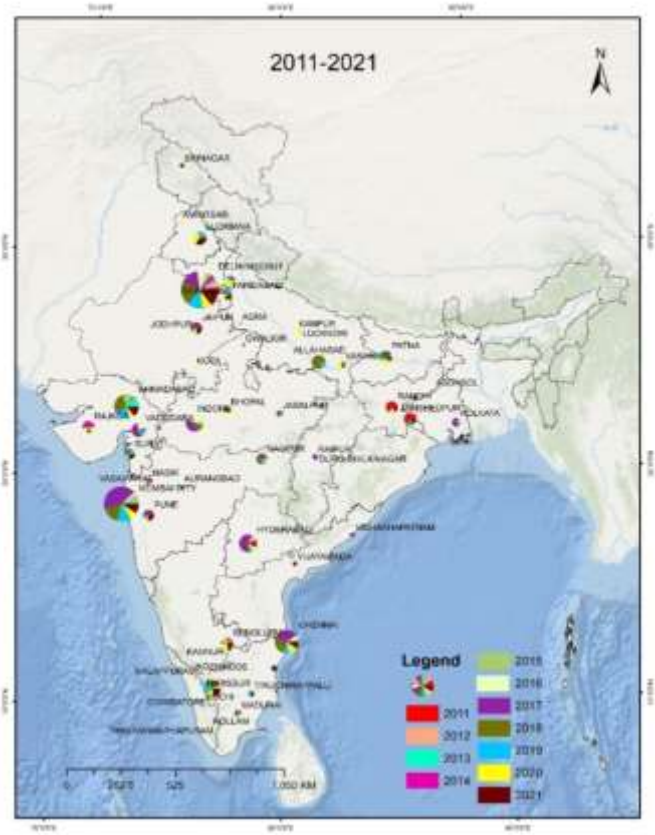


Data Source: HLRN, 2018, 2019, 2020, 2021 & 2022

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

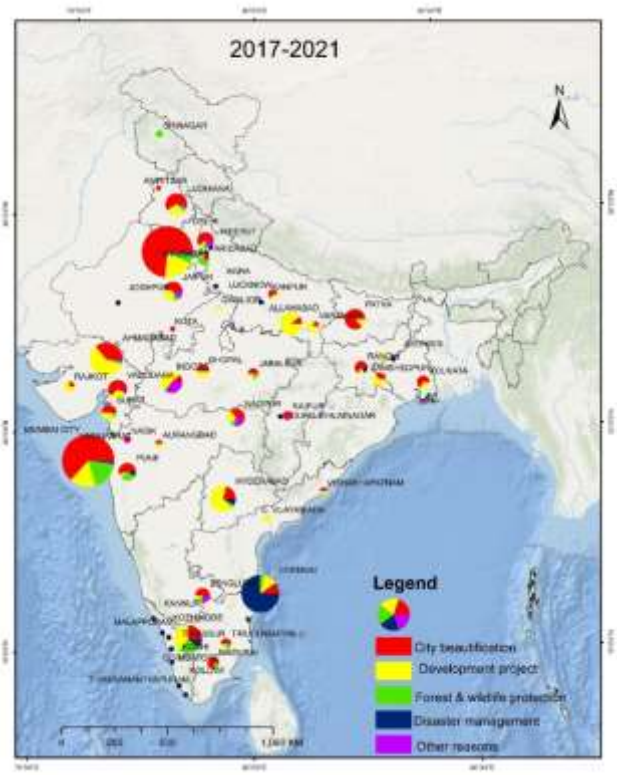
There is a noticeable increase in the percentage of metropolitan cities with slum eviction during 2017-2021. The overall trend during this period suggests that slum eviction is a widespread and persistent issue in urban India, affecting millions of people living in informal settlements and vulnerable to displacement and homelessness (Map No.2).

Map No. 1:
Slum Eviction Cases in Metropolitan Cities of India from 2011-2021



Data Source: Housing & Land Rights Network, 2018, 2019, 2020, 2021 & 2022

Map No.2: Slum Eviction Cases in Metropolitan Cities of India from 2017-2021 (Based on Causes of eviction)



Data Source: Housing & Land Rights Network, 2018, 2019, 2020,2021 & 2022

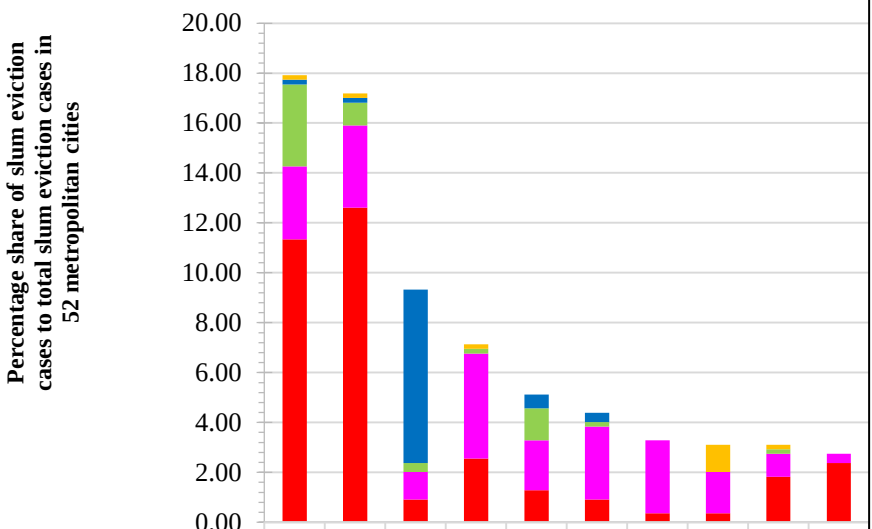
Trend of slum eviction in metropolitan cities during 2017-2021:

1. ***City Beautification:*** City beautification has been the most frequent and dominant cause of slum eviction across the years. These are slum eviction cases where the reason cited is the beautification or improvement of the city's appearance. This could involve clearing slum settlements to make way for urban development or aesthetics. Mumbai, Delhi, Ahmedabad, Ludhiana, Patna and Coimbatore witnessed majority of the slum eviction cases due to city beautification (Map No. 2, Figure No. 5 & 6).
2. ***Development Project:*** Slum evictions categorized under development projects indicate that the land occupied by slums was needed for urban development initiatives. Mumbai, Delhi, Ahmedabad, Coimbatore, Hyderabad, Allahabad, Indore

and Ludhiana, witnessed slum eviction cases due to development projects and infrastructure development (Map No. 2, Figure No. 5 & 6).

3. ***Forest & Wildlife Protection:*** Some eviction cases may be related to environmental conservation efforts, particularly protecting forests and wildlife which has been a reason of many slum eviction in Mumbai, Delhi and Coimbatore (Map No. 2, Figure No. 5 & 6).
4. ***Disaster Management:*** Evictions under this category might be linked to disaster management activities, possibly for creating disaster-resistant zones or managing risk-prone areas as taking place in Chennai and in Hyderabad and Coimbatore to some extent (Map No. 2, Figure No. 5 & 6).

Figure No.5: Share of slum eviction cases in top 10 metropolitan cities to total slum eviction cases in 52 metropolitan cities during 2017-21



	Mumbai UA	Delhi UA	Chennai UA	Ahmedabad	Coimbatore UA	Hyderabad UA	Allahabad UA	Indore UA	Ludhiana (M Corp.)	Patna UA
Other reasons (%)	0.18	0.18	0.00	0.18	0.00	0.00	0.00	1.10	0.18	0.00
Disaster management (%)	0.18	0.18	6.95	0.00	0.55	0.37	0.00	0.00	0.00	0.00
Forest & wildlife protection (%)	3.29	0.91	0.37	0.18	1.28	0.18	0.00	0.00	0.18	0.00
Development project (%)	2.93	3.29	1.10	4.20	2.01	2.93	2.93	1.65	0.91	0.37
City beautification (%)	11.33	12.61	0.91	2.56	1.28	0.91	0.37	0.37	1.83	2.38

Data Source: HLRN, 2018, 2019, 2020, 2021 & 2022

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

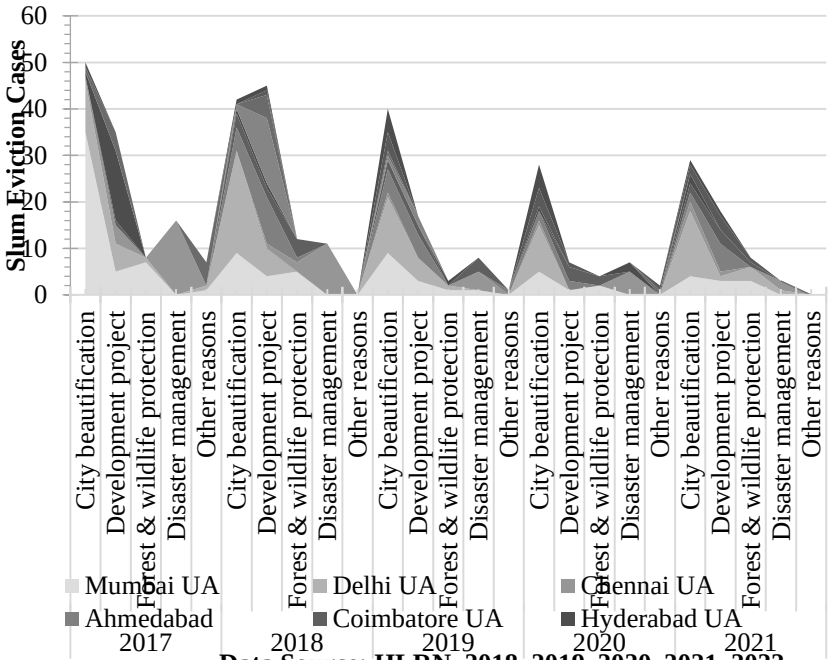
Other Reasons: This category encompasses eviction cases where reasons other than the specified categories were cited as in Indore, Ahmedabad, Mumbai and Delhi (Map No. 2, Figure No. 5 & 6).

Some metropolitan cities have low or no slum eviction cases during this period, suggesting different approaches to informal settlements or fewer instances of forced eviction.

During 2017-21, Mumbai and Delhi have the highest total slum eviction cases, with 98 and 94 cases, respectively, during this period. Both cities have cited various reasons for evictions, including city beautification and development projects. Chennai has a significant number of slum eviction cases (51) mainly attributed to disaster management activities (38 cases). This suggests a focus on mitigating risks in disaster-prone areas. Ahmedabad has seen 39 slum eviction cases, primarily related to development projects and city beautification (Map No.5 & Figure No. 6).

Figure No.4 illustrates that the top 5 metropolitan cities in India accounted for a majority of slum eviction cases between 2017 and 2021. The total share of slum eviction cases of the first five ranked cities had increased from 72.29% in 2017 to 85.05% in 2018, and then decreased to 67.42% in 2019 (Figure No. 4). However, it further decreased to 66.67% in 2020 and 65.85% in 2021, indicating a more dispersed distribution of slum eviction cases across the country (Figure No. 4).

Figure No. 6: Slum Eviction Cases by Cause of Eviction in top 10 Metropolitan Cities of India, 2017-21



Data Source: HLRN, 2018, 2019, 2020, 2021, 2022

Delhi UA and Mumbai UA have consistently been the top two cities with the highest percentage of slum eviction cases in each year, with Delhi UA surpassing Mumbai UA in 2018 and maintaining the lead ever since (Figure No. 4). Chennai UA, Ahmedabad and Coimbatore UA have also appeared frequently in the top five ranked cities, with Chennai UA being the only city to be present in all five years. Hyderabad UA, Indore UA and Allahabad UA have seen a sharp decline in their percentage of slum eviction cases after 2017, while Ghaziabad UA, Ludhiana (M Corp.), Patna UA and Bangalore UA have emerged as new entrants in the top ten ranked cities in 2020 and 2021 (Figure No. 4).

There are a number of reasons why slum eviction cases are so high in these cities. One reason is that these cities are home to a large number of slums. According to the National Sample Survey Office, there were an estimated 1.19 crore slum households in India in 2011. Of these, 43.5 lakh households were located in the top 5 metropolitan cities. Another reason for the high number of slum eviction cases in these cities is that they are undergoing rapid urbanization. This urbanization is leading to a shortage of affordable housing, which is forcing slum dwellers to live in precarious conditions.

Relevant Issues of Forced Eviction:

Negative consequences of slum eviction:

The high number of slum eviction cases in these cities have a number of negative consequences. These include:

1. Displacement of slum dwellers, which can lead to loss of livelihood, housing, and social networks.
2. Increased vulnerability to poverty and homelessness.
3. Increased social and economic inequality.
4. Damage to the environment, as slum dwellers are often forced to live in environmentally degraded areas.
5. Deprives from various means of income

Slum Eviction Laws, State Influence on Housing Adequacy and Rights in India:

The state plays a decisive role in defining formal and informal housing, significantly influencing the adequacy of housing. The UN Habitat primarily assesses adequacy based on infrastructure and secured tenure. The state's categorization of informality determines which informalities are tolerated or considered expendable. Affluent residents often obtain leniency, while forced slum evictions disproportionately impact marginalized groups, resulting in human rights violations. Although the Indian Constitution does not explicitly acknowledge the right to adequate housing, the Supreme Court interprets it under Article 21, emphasizing the 'right to shelter,' and Article 19(1), guaranteeing the freedom to move and reside. Various legislations, including the National Housing Policy (1994), National Urban Housing & Habitat Policies (1998, 2007), and the Right to Fair Compensation and Transparency in Land Acquisition Act (2013), address housing issues. The latter prioritizes protecting land rights, regulating land acquisition, and highlighting transparency, social impact assessments, and resettlement for affected individuals. However, the law includes exceptions for specific legislations, constraining its overall effectiveness (Vipra, T. 2022).

Resettlement Criteria- An opportune device to avoid resettlement:

Out of those forcefully evicted, fractional part of them is rehabilitated. In many cases the ‘eligibility criteria’ of providing supporting documents of citizenship becomes a legitimate tool for acquiring resettlement for the evictees. Evicted residents with dearth of documents are excluded in government inspection even if they had possessed the house for an extensive period. For example, of the 1200 families who were evicted for Kolkata Book Fair in Salt Lake, Kolkata, only 113 had become eligible for resettlement.

Implications for Policy and Decision-making:

Government Initiatives:

Jawaharlal Nehru National Urban Renewal Mission (JNNURM): Launched in 2005, this mission aimed to improve infrastructure and services in slums and provide basic amenities like water supply, sanitation, and affordable housing. Under JNNURM, funds

were allocated to states and cities for slum rehabilitation and upgrading.

Rajiv Awas Yojana (RAY): Launched in 2013, RAY was designed to make India slum-free by providing affordable housing with basic services to slum dwellers. It focused on a "slum-in-situ" approach, which means the rehabilitation of slums at the existing location or nearby through land tenure rights and provision of basic services.

"inclusive growth" approach: Since the twelfth Plan onwards, the Government has taken an "inclusive growth" approach as the overriding paradigm of development. Affordable Housing has been one of focus areas for the government. One such key initiatives is the Pradhan Mantri Awas Yojana (PMAY- 2015) to address the inadequacies of the former programs and to develop an all-inclusive scheme through four models: In situ Slum Redevelopment, Affordable Housing in Partnership and Subsidy for beneficiary-led individual house construction and Credit linked subsidy. Launched in June 2015 the scheme aimed to build 20 million houses for people who belong to the Economically Weaker Section (EWS) and Low-Income Groups (LIG). Under PMAY-Urban, slum rehabilitation projects aimed to be implemented through public-private partnerships and community participation.

Slum Rehabilitation Authority (SRA): Some states like Maharashtra have established specialized bodies like SRA to supervise and implement slum rehabilitation schemes. These authorities work towards rehabilitating slums by providing improved housing and infrastructure while ensuring the involvement of slum dwellers in the decision-making process.

Land pooling and land-sharing policies: Some cities, like Chennai and Mumbai, have implemented land pooling and land-sharing policies for slum rehabilitation. These policies involve acquiring land from slum dwellers, providing new housing units, and utilizing the remaining land for commercial purposes to fund the rehabilitation process. In spite of these initiatives, challenges such as lack of adequate funds, slow implementation, resistance from slum dwellers, and difficulties in acquiring suitable land persist. The government continues to strive for innovative solutions and partnerships to ensure a more sustainable and effective slum rehabilitation policy in the country.

Improving Governance, Accountability, and Transparency:

Immediate attention needs to be paid for a holistic, transparent and sustainable approach to the problem of slum eviction and housing shortage. There are needs of policy and institutional interventions to synchronize State policies with Central policies for Affordable Housing, creating the transparent beneficiary database, strengthening the capacities of implementing Agencies, developing a mechanism to access to low-cost construction finance, developing access to credit to the beneficiary and focus on long-term sustainable mechanisms.

Modification in Resettlement Policies:

The slum residents who are evicted, only a handful of them get resettled, and

that too ineffectively. 'Entitlement criteria' becomes a suitable tool for authorities to evade resettlement – residents who lack IDs or were left out in government surveys are excluded, even if they had owned the house for long. For example, out of the 1,200 families who were evicted for Kolkata Book Fair, only 113 families were entitled for resettlement. Also, when resettlement is provided, it would be in low-quality selected spots in city outskirts. In some cases, the consequences have been shocking – such as the case of slum residents resettled around polluted category industries in Mahul in Mumbai, where residents had been prone to disease caused by industrial pollution. Some governments also commanded payment for the new houses, which the poor cannot afford. For eg., in Delhi, non-reserved category families required to pay an additional Rs 1.42 lakh for an alternative flat.

Informal settlements across India evolve gradually through the efforts of their residents. As a result, housing policies should alter their focus from purely physical housing provision to encompass greater control and security over the land that these communities occupy. Notable instances of such policy initiatives are found in the Punjab Slum Dwellers (Proprietary Rights) Act (2020) and the Odisha Land Rights to Slum Dwellers Act (2019). These judicial acts offer valuable models for addressing housing issues and mitigating evictions. They empower communities that have incrementally developed housing on government or private land by yielding household titles, safeguarding them against eviction threats, facilitating access to formal housing financing, endorsing land purchase and sale rights after a restricted period, and qualifying residents for various subsidies.

The government needs to modify its "slum eviction" approach and move beyond the slum upgradation and redevelopment. It needs to change its viewing platform from a curative to a preventive approach to urban development and infuse and promote technology for ease of living. For instance, Tamil Nadu has been familiarizing and executing new low-cost sustainable practices to ensure affordable housing through construction of eco-friendly Light House Projects (Government of India, 2022). Also, low-cost Rental Housing Schemes could be introduced for the slum dwellers.

Conclusion:

The slum evictions establish that the slum evictees face an uncertainty about the future with their habitable space turned into debris. In most instances they have either been forced to be homeless or forced to resettle in the city periphery. Demolition swiftly swells into a key issue with political parties supporting or contradicting the issue. Nevertheless, the evictees do not gain whatsoever from such political rivalries. Rather they are psychologically and emotionally blackmailed in many cases with false promises of gaining rehabilitation. The process of demolition of shelter is itself an issue of impoverishment.

However, the continuing informal slum eviction drives, urban housing shortage in Indian

cities calls for comprehensive transformation of urban space focusing on the informal settlements. Forced evictions can be replaced by more rational and holistic sustainable programs, such as slum upgrading and neighbouring relocation. It highlights the requirement of adequate housing in protecting the human rights to shelter, health, life, work, and education.

It is to be noted that the focus of developmental activities is oriented towards the metro cities getting the lion's share of monetary allocation for development, while the rural areas, small and medium towns are mostly ignored and left behind. If the focus of development is holistic and inclusive of the rural areas, small and medium towns, then it can surely reduce the flow of rural-urban migration towards the metro cities. This in turn can reduce the population pressure on the metro cities and slower the process of informal slum growth.

The practice of filtering the undesirable slums in the metropolitan cities is expected to linger in light of the government programmes affirming the dream of achieving the status of world-class city, through the smart cities mission or renovation of government lands in the city, infrastructural development and judicial efforts in the name of environmental protection.

By examining the challenges of slum eviction in metropolitan cities of India from 2011 to 2021, this research paper highlights the urgent need for inclusive policies that address the underlying causes and mitigate the socio-economic consequences of slum eviction. The study emphasizes the importance of all-encompassing urban development, participatory approaches, and effective execution of housing and rehabilitation programs. Furthermore, it underlines the significance of political will, virtuous governance, and stakeholder alliance to ensure sustainable resolutions to the challenges of slum eviction in metropolitan cities of India. Further research should build upon these findings to evaluate the efficacy and long-term impression of policy interventions in this arena.

References:

1. Aluwalia, P. (2019). Eviction and Urban Poverty in India: A Case Study of Slum Dwellers in Delhi. Journal of South Asian Studies, 42(2), 267-285.
2. Desai, R., & Potdar, B. (2018). Struggles, Strategies, and Coping Mechanisms: A Study on Slum Evictions in Ahmedabad, India. Urban Policy and Research, 36(3), 1-17.
3. Dhar, B. (2017). From Nuisance to Villains: Slum Eviction Policies in India. Economic and Political Weekly, 53(23), 19-21.
4. Fisher, S., & Premalatha, M. (2017). Urban Slum Evictions in South Asia: A Comparative Analysis of India, Bangladesh, and Sri Lanka. Economic Geography, 54(3), 303-327.
5. HLRN (2018). Forced Eviction in India, 2017: An Alarming National Crisis. New Delhi: HLRN. https://www.hlrn.org.in/documents/Forced_Evictions_2017.pdf

6. HLRN (2019). Forced Eviction in India, 2018: An Unabating National Crisis. New Delhi: HLRN https://hlrn.org.in/documents/Forced_Evictions_2018.pdf
7. HLRN (2019). Adjudicating the Human Right to Adequate Housing: Analysis of Important Judgments from Indian High Courts. New Delhi: HLRN. https://www.hlrn.org.in/documents/Housing_Judgments_India.pdf
8. HLRN (2020). Forced Eviction in India, 2019. An Unrelenting National Crisis. New Delhi: HLRN. https://hlrn.org.in/documents/Forced_Evictions_2019.pdf
9. HLRN (2021). Forced Eviction in India, 2020: A Grave Human Rights Crisis During the Pandemic. New Delhi: HLRN. https://hlrn.org.in/documents/Forced_Evictions_2019.pdf
10. HLRN (2022). Forced Eviction in India, 2021. New Delhi: HLRN. https://www.hlrn.org.in/documents/Forced_Evictions_2021.pdf
11. Human Rights Law Network (2006). Eviction Watch: Part II. HRLN: New Delhi. https://slic.org.in/uploads/2021/02-February/10-Wed/eviction%20watch.pdf
12. Jha, A. & Lakhan, A. (2018). Is Indore's 'Smart City' Drive All About Forced Evictions? The Wire. https://thewire.in/urban/is-indores-smart-city-drive-all-about-forced-evictions
13. KPMG (2014). Decoding-Housing-for-all-2022. Mumbai: KPMG. https://assets.kpmg.com/content/dam/kpmg/pdf/2014/09/Decoding-Housing-for-all-2022.pdf
14. Navya, P.K. (2018). Where goes the slum dweller evicted in Indian cities? Citizen Matters. https://citizenmatters.in/slumdweller-eviciton-smart-city-beautification-2017-india-6732
15. NBO (2012). Report of the Technical Group on Urban Housing Shortage (2012-17). New Delhi: NBO, Ministry of Housing & Urban Poverty Alleviation, Government of India. https://nbo.gov.in/pdf/urban-housing-shortage.pdf
16. NBO (2012). Slums in India, A Statistical Compendium 2011. New Delhi: NBO, Ministry of Housing & Urban Poverty Alleviation, Government of India. https://nbo.gov.in/pdf/Slum_in_india_2011_english_book_23_May_12.pdf
17. NBO (2015). Slums in India, A Statistical Compendium 2015. New Delhi: NBO, Ministry of Housing & Urban Poverty Alleviation, Government of India. https://nbo.gov.in/pdf/SLUMS_IN_INDIA_Slum_Compendium_2015_English.pdf
18. Ron Mahabir, Andrew Crooks, Arie Croitoru & Peggy Agouris (2016). The study of slums as social and physical constructs: challenges and emerging research opportunities, Regional Studies, Regional Science, 3:1, 399-419. https://doi.org/10.1080/21681376.2016.1229130
19. Saleh, M. A. (2019). Revisiting the Nexus of Slum Eviction, Unemployment, and Urban Poverty: A Case Study of Mumbai. Journal of Asian and African Social Science and Humanities, 2(1), 14-30.

20. Srinivas, H., & Sivaramakrishnan, K. C. (2017). Slum Rehabilitation and the Politics of the "Civilized City" in Mumbai. Economic and Political Weekly, 52(4), 53-61.
21. Citizen Consumer & Civic Action Group, (2015). Eviction Mapping: Uncovering Chennai's Invisible Injustice. Chennai: The Public New sense. https://www.cag.org.in/sites/default/files/2020-11/cag_newsletter_apr-jun2015.pdf
22. UNHABITAT (2010). Planning Sustainable Cities, UN-HABITAT Practices and Perspectives. Nairobi: UNHABITAT. file:///C:/Users/swati/Downloads/PlanningSustainableCities.pdf
23. UNHABITAT (2022). World Cities Report 2022, Envisaging the future of cities. Nairobi: United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf
24. Vipra, T. (2022), Eviction and Housing Laws in India. New Delhi: Social and Political Research Foundation. https://sprf.in/wp-content/uploads/2022/01/SPRF-2022_IB_Evictions-and-Housing-Laws.pdf

INDEX

Accuracy Assessment	37, 41,276
Acidic	85, 98
Action Research	66, 242
Adalpur	247
Advanced Vegetation Index	24, 26, 29
Aerial Aspects	50,
Afforestation	17, 20
Aggradations	56
Agricultural Area	84, 118, 139, 189, 253
Agricultural Development	139, 171, 178
Agricultural Drought	139
Agriculture	21, 42, 74, 103, 109, 124, 139
Agro-Climatic	124, 128
Agrometeorology	139
Ahirwati	249
Ahmednagar	1, 177, 181, 199
Air Length	62,
Albedo	12, 13, 17
Alluvial	59, 60, 105, 135
Alluvial Banks	60
Alluvial Soil	127, 132
Aquifers	66, 69
Arcgis	35,37,103, 210, 228,
Areal	46, 125
Artificial Intelligence	237, 244
Assam	224,227, 247
Assessment	18, 30, 37, 56, 223
Atmospheric Correction	23
Banganga	34
Bare Soil Index	25, 27, 29
Barren Land	32, 28, 40

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Basin 3, 25, 45, 116, 127
Bhima 4, 9, 45, 51, 117
Bhimashankar 46
Bhogwati 47
Bhugolshastra 2, 63, 123
Bifurcation 45, 49
Biodiversity 10, 167, 200
Biography 1, 10
Bone 166, 170
Bone Manure 166
Brahmaputra 224, 227
Built-Up 13, 32, 40, 199, 208
Canopy 270
Carbon 10, 11, 12,16
Cardamom 74
Cartosat 58, 103
Catchment 22, 47, 94, 100
Catchment 22, 47, 224, 229
Categorization 21, 95, 247, 273
Census 117, 141, 179, 203
Chandani 8, 47
Change Detection 52, 207
Changing Trends 235
Channel 25, 50, 58, 226
Channel Index 62
Channel Length 61
Check Dams 87, 138
Chemical 113, 166
Circular Shape 51
Circularity 48, 51
Circulatory Ratio 43
City Periphery 297
Climate 174, 212

Climate Change. 98, 212
Climatic Conditions 12, 199
Climatic Elements 125
Combating Trafficking 263
Commercial 212, 222
Communication 2,35,242
Compost 166, 168
Compost Manure 166, 167
Conference 2, 5, 252
Confluence 46, 51, 88
Conservation 101, 114, 140
Consumer Adoption 155, 161
Coordinator 71
Corruption 280
Cow Dung 166, 169
Crop 140, 166
Cross-Section 263
Crystalline Metamorphic 101
Cultivable 116, 118
Cultivation Pattern 122
Daund 1, 45, 117
Deccan Traps 24
Delhi 56, 123, 140
Demographics 102, 148
Density 145, 177, 217, 273
Departmental Stores 142, 143
Development Planning 63, 125
Dharuhera 247, 252
Digital Elevation Model 268, 270
Digitization 48, 205
Discharge 226, 230
Downstream 46, 56
Drainage 58, 85, 90, 183, 250

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Drainage Characteristics 45
Drainage Density 45, 52, 228
Drainage Texture 48, 52
Drilled Bore Wells 111
Drinking 67, 114, 183
Driving Forces 32
Drought 34, 63, 97, 117
Drought-Prone 34, 69
Drugs 166
Dung-Cow Urine 166
Earth 141, 175
Eco-Friendly 156, 138
Ecological Structure 166
Economic 177, 200, 215
Economic Development 32, 257
Ecosystem 218, 222
Ecosystems 166, 222
Electric Vehicles 155, 157
Elongated Ratio 45
Elongation 52
Empirical 231, 155
Entrepreneurship 256, 259, 263
Environment 11, 17, 33, 69, 157, 162
Environment Relationships 244
Environmental Concern 156
Environmental Factors 101, 162, 244
Environmental Protection 156, 298
Equatorial 20
Equilibrium 57, 61
Erdas 57, 251,
Erosional 45, 207, 231
Evapotranspiration 12, 270
Evolving Lifestyles 141, 145

ISBN: 978-93-94819-25-2,
Advances in Geographical Research

Facilities 13, 138, 142
Fallow Area 118
Fallow Land 120
Farm 139
Farmland Fertility 166
Fertilizers 166, 170, 171
Financial 157, 232
Flash Flood 8,232
Flash floods 225, 230
flood hazard zones 229, 230
Floodplain 224, 232
Floods 44,56,60, 224, 230
Flow 261, 263
Flow Accumulation 58, 228
Fluvial Geomorphic Cycle 52
Forced Slum Eviction 280, 295, 300
Forest 229, 266
Forest Canopy Density 20, 23, 27, 30
Forest Fragmentation 21, 30
Form Factor 45, 51
Fossil Fuels 12, 155
Frequency 45, 51, 54, 225, 173
Geographic Coordinate System 23
Geographical Area 22, 52, 106
Geographical Information System 20, 54
Geography 123, 141, 186, 199
Geoinformatics 247, 253
Geo-Location 70
Geology 46, 90
Geomorphology 2, 5, 8, 54, 104, 126
Geoprocessing 57, 278
Georeferencing 205, 269, 276
Geospatial 64, 101, 111, 267

Geospatial Approaches 101
Geo-Tagging 70
Ghod 47, 116
Global 143, 156
Global Community 262
Global Positioning System (Gps) 101, 102
Global Status 280
Global Warming 12, 245
Gondwana Supergroup 90
Government 161, 189
Government Policies 155, 280, 285
Green Infrastructure 18
Green Manure 166
Green Organic 166, 169
Green Revolution 124, 169
Greenhouse Gases 155, 222
Haryana 247, 249
Healthcare Access 255, 262
Hindi 247
Homeless 284, 289
Housing Challenges 260, 262
Human 257, 261
Human life 144, 155, 200, 224
Human Rights 261, 295
Humidity 34, 185, 227
Hydraulic 56, 61
Hydrogeological 46
Hydrological 46, 61, 100, 113, 261
Impervious Surfaces 14, 15, 16
India 280, 281, 189
Indrayani 47
Industrial 99, 247
Influence 11, 26, 295

Informal Settlements 283, 293
Interconnected 67, 141, 255
Interdisciplinary 44, 198
International 198, 206
International Cooperation 261, 263
Irrigation 34, 99, 123, 139
Jamkhed 117
Jiadhal River 224, 229
Kappa Coefficient 32, 41
Karjat 116, 122
Karnataka 10, 46, 47
Khed 117, 121
Kml 250
Kolhapur 1,32
Krishna 155, 300
Kundali 47
Labor Market 256, 261
Land Cover 10,32, 41, 199
Land Resource 101, 275
Land Use 103, 117, 175, 211, 228
Landforms 45, 111, 126
Landsat Imagery 33
Landscape 149, 152
Latitude 22, 85, 102
Lengths 23, 48, 50
Levees 63
Liberalization 247, 252
Linear 15, 46, 172
Lithology 45
Livelihood activities 232
Livestock 225, 232
Longitude 46, 92, 141
Longitudinal Profile 56, 59

Maharashtra	34, 52, 101, 178
Man	47, 51
Management	63, 102, 118
Mann Kendall Trend Test	58
Mathematic	45, 236
Maximum Likelihood Classifier	35
Meandering	62
Medicines	266, 192
Metropolitan	204, 180
Metropolitan Cities	280, 290
Microclimate	16, 17
Migration Dynamics	255
Migration Flows	261, 263
Mitigating	285, 293
Miyawaki Forest	17
Monsoon	22, 98, 146
Monsoon season	34, 63, 107
Morphology	275, 234
Morphometric	45, 112
Mosaic	251
Moshi	47
Mula	46, 50, 52
Mumbai	99, 146, 183
Municipal Boundaries	250
Mutha	46, 50, 146
Nandurbar	20, 29
National	47, 211, 248
Natural Science	240, 244
Net Sown Area	116, 120
Nira	34, 51
Niranarshingpur	47
Non-Spatial Data	247, 250
Normalized Difference Vegetation Index	23, 29, 275

Nutritional 124, 167
Order 179, 261
Organic 163, 171
Organisms 166, 217
Outreach Program 2
Pabal 116
Parner 117
Pawana 47
Phaltan 32, 34, 40
Physical 168, 203
Planning Infrastructure 262
Policy Landscapes 280
Policymakers 262, 280, 283
Population 210, 243
Population Growth 32, 141, 196
Population Growth 32, 141, 213
Poverty Alleviation 255, 299
Poverty Reduction 256, 260
Preservation 32
Projects 210, 236
Psychologically 226, 297
Public 284, 300
Pune 1, 45
Quality Education 255, 258
Quantitative 45, 175, 241
Raichur 46
Rainfall 52, 95, 132
Rapid 139, 208, 248, 278
Recreational 186, 252
Reduced Inequality 255, 259
Reforestation 20
Rehabilitation 280, 296
Remote Sensing 20, 102

Research 117, 139
Residential 142, 153
Resource 12, 256
River 21, 45, 56, 216
Robust Institutions 263
Satara 3, 32, 54
Satellite Image 238, 250
Savitribai Phule 1, 147
Sediment 56, 105
Sediment deposition 224, 230, 232
Sediment Load 232
Shadow Index 25, 27
Shirur 116, 122
Shivaji 1, 32, 54
Shrigonda 116, 120
Silent Catastrophe 280
Sina 47
Sinuosity Indices 56, 61
Skill Transfer 257, 262
Slope 24, 228, 273
Slum Rehabilitation 280, 300
Smuggling 261, 263
Social Activities 244
Social Behavior 239, 244
Social Cohesion 260, 262, 263
Social Sciences 234, 240
Socioeconomic 224, 287
Soil 17, 83, 109
Sophisticated 116, 149
Spatial Data 250, 277
Spatial Variation 23
Spatio-Temporal Changes 256
Spectral Indices 23, 26, 27

Stakeholder 298
Statistical 35, 58, 247
Stream 45, 52, 97,225
Stream Length Ratio 45
Stream Order 45, 48, 50
Summer 107, 135, 146
Superannuation 2
Supervised Classification 32, 273
Sustainable 264, 280
Sustainable Development 32, 58, 355
Sustainable Development 54, 102, 255
Sustainable Urban Development 10, 260
Sustainable Urbanization 255
Teaching 1
Technology 21, 32, 155
Temperatures 10, 14,97
Temporal Changes 21, 33, 254
Texture 37, 52, 85
Thamini 47
Three Dimensionless Ratios 51
Time-Series Data 277
Topographical Maps 47, 202
Topography 52, 169
Toranmal 20, 24,30
Toranmal Forest Range 20, 23,29
Town 57, 92, 184
Transparency 280, 296
Transportation 199, 108, 213, 225
Tropical Deciduous 20, 26, 27
Tropical Evergreen 20
Tropical Rainforest 20, 31
Ujjani Dam 46, 47
Uncultivable 116, 117

Universal Transverse Mercator 103
Unsanitary 280
Unsupervised 33, 116, 173, 175
Urban 33, 40, 141
Urban Development 280, 291, 297
Urban Forest 10, 11, 17, 18
Urban Geomorphology 2
Urban Growth 32, 40, 199
Urban Heat Island 10, 12, 17
Urban Planners 280
Urban Policy 280
Urban Sprawl 14, 199
Urbanisation 199, 106, 247
Urbanizatio 10, 32, 141, 200, 226
Usable Goods 12, 18
Utilities 145, 247
Vacant 200, 247, 252
Vegetation 13, 20, 138, 270
Vermicomposting 166, 169
Vulnerabilities 257, 262
Vulnerability 228
Waingangā 56, 57, 62
Water 63, 68, 90, 183
Water Availability Analysis 104, 111
Water Discharge 257, 262
Water Discharge 67, 104
Water Inflow 102, 111
Water Resource Management 46, 58, 114
Water Towers 67, 98
Waterbody 32, 40
Watershed Management 2, 9
Weather 107, 226
Weather Changes 12, 116

Weighted Overlay 20, 228
Western Ghats 31, 46, 47
Wildfire 10, 270
Winter 11, 23, 97, 227

Sr. No.	List of Reviewers
01	**Dr. Bhaskar Ramchandra Nikam** Deputy Director, Earth Observation and Disaster Management Support Programme Office, ISRO HQ, Bengaluru, India
02	**Prof. (Dr.) Sudhakar Pardeshi** Head, Department of Geography, Savitribai Phule Pune University, Pune, Maharashtra India
03	**Prof. (Dr.) Virendra Ramchandra Nagarale** Senior Professor and Head, Department of Geography SNDT Women's University Karve Road Pune Campus Pune (MS) India
04	**Prof. (Dr.) Anuja Tigga** Professor Department of Geography, Andhra University, Andhra Pradesh, India
05	**Prof. (Dr.) Suresh K. Pawar** Professor & Head, Department of Geography, Shivaji University, Kolhapur, Maharashtra India
06	**Prof. (Dr.) Ashish Sarkar** Professor and HoD (Retired), Department of Geography, Presidency University, Kolkata, West Bengal, India
07	**Dr. Rajesh Kumar Abhay** Associate Professor, Department of Geography, Dyal Singh College, University of Delhi, India
08	**Prof. (Dr.) Avinash Kadam** Professor & Director, School of Earth Sciences, Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India
09	**Sri. Biswajit Roy Chowdhury** Chairperson, South Asian Institute for Advanced Research and Development (SAIARD), Kolkata, West Bengal 700047, India
10	**Smt. K.L. Wathsala Gunathilake** Department of Geography, University of Kelaniya, Kandy Rd, Kelaniya 11600, Sri Lanka
11	**Prof. (Dr.) Ajay Kamble** Head, Department of Geography, Bhavans College, Mumbai**,** Maharashtra, India
12	**Prof. (Dr.) Balasaheb S. Jadhav** Professor, Department of Geography Shri Vijaysinha Yadav College, Peth Vadgaon, Dist. Kolhapur-416112, Maharashtra, India
13	**Prof. (Dr.) Narke Sunil Yuvraj** People Education Society Jamkhed, College Addr: Jamkhed Tal: Jamkhed, Dist: Ahmednagar Pincode: 413201
14	**Prof. (Dr.) Arjun Baban Doke** Department of Geography, Babauraoji Gholap College / University, Sangvi, Maharashtra, India
15	**Dr. D. H. Pawar** Associate Professor, Department of Geography, Shivaji University, Kolhapur, Maharashtra, India
16	**Dr. More Jyotiram Chandrakant** Associate Professor, Department of Geography, Bharatiya Jain Sanghatana's Arts, Science & Commerece College, Wagholi, Pune, Maharashtra, India
17	**Dr. Basudeo Prasad** Associate Professor, Department of Geography, J.J. College College, Gaya, Bihar, India

18	**Dr. Atul Mohanrao Jethe** Associate Professor Department of Geography, C.T.Bora College, Shirur Dist-Pune, SPPU, India
19	**Dr. Madanlal V. Suryawanshi** Assistant Professor and Head, Department of Geography, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, India
20	**Dr. Avinash Talmale** Assistant Professor, Department of Geography, Vasantrao Naik Government Institute of Arts And Social Sciences, Nagpur
21	**Dr. Barkade Jagannath Dagadu** Assistant Professor, Department of Geography, Raja Shripatrao Bhagwantrao Mahavidyalaya, Aundh, Shivaji University Kolhapur, Maharashtra, India
22	**Dr. Ashali Chandrakant Kharke** Assistant Professor, Department of Geography, K.V.N.Naik College, Nashik, India
23	**Dr. Subhash Vishnu Karande** Assistant Professor, Department of Geography, Chhatrapati Shivaji College, Satara, Maharashtra, India
24	**Dr. Pragati Deshmukh** Assistant Professor, Department of Geography, HPT Arts and RYK Science college, Nashik, Maharashtra, India

About the book

Explore the rich tapestry of geographical research in the Indian subcontinent with ‘Advances in Geographical Research', a felicitation volume dedicated to Professor Maya G. Unde of B.P.H.E. Society’s Ahmednagar College, Savitribai Phule Pune University, India. Celebrating her remarkable contributions, this comprehensive volume explores both Physical and Human Geography across regions. Delve into cutting-edge investigations such as Remote Sensing and GIS, gaining a profound understanding of environmental and societal interactions. The anthology features original contributions on topics like urban heat island, flood geomorphology, land use change, urbanization, land suitability analysis, agro-climatic planning, adoption of electric vehicles, sustainable development goals and more, presenting either functionally informative or intellectually stimulating papers. Embark on a scholarly journey through India's landscapes, from the Himalayas to coastal plains, unravelling geographical intricacies. Whether you're a seasoned geographer, research scholar, student or enthusiast, this edited volume serves as a beacon of knowledge, reflecting the dedication and expertise of the contributors.

Jyotikiran Publication, Pune
Sr. No. 204, Sahajeevan Society,
Bhekrinagar, Hadpsar, Pune-8
Mob- 8888454089
Email- jyotikiranpublicationpune@gmail.com

ISBN 978-93-94819-25-2